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History of Motion-Picture Studio Lighting

By CHARLES W. HANDLEY

Historically, the use of artificial light in the motion-picture industry has followed a number of recurring cycles. The use of various types of lighting equipment has not always been a matter of evolution. On several occasions there has been a revolution in which carbon arcs were moved down from the top place by incandescent tungsten lamps and vice versa. The influences behind these cyclic changes were the advent of panchromatic film, the arrival of sound, the application of three-color photography, and finally an economic factor which resulted in a major change in the spectral sensitivity of all color films. During these various cycles, illuminants such as mercury tubes, fluorescent tubes and even mercury combined with other gases were experimented with, or used to some extent, but the main artificial light sources were carbon-arc lamps and incandescent tungsten lamps, used separately or in combination, and with one source or the other usually in a dominant position.[1,5,6,7,20,28]

THE ENERGY with which some people have attempted to reduce motion-picture set lighting to a strictly mechanical function indicates that the importance of light in motion-picture photography was probably not fully appreciated even by some of the people who depended upon the control of light for their livelihood. Basically, the visual part of the illusion we call the motion picture is nothing but the accurate control of light.

In modern motion-picture photography, light from the sun, light from the carbon arc or light from incandescent tungsten is directed to the object to be photographed. By reflection, this light is redirected to the film where it provides a photochemical reaction. The film, so modified, acts as a filter to control the intensity and quality of light from a projector. The modified projected light that is left after it has passed through the film is reflected from the screen to the eyes of the audience where it again makes an impression which should coincide dramatically with the original action. It would all be a simple matter of floodlighting if the word "dramatically" did not carry such strong implication. In order to enhance dramatic action the cinematographer must have as perfect control of the quality and quantity of light as possible.

A natural desire on the part of production units to simplify lighting to the extent of a pushbutton formula and to arrive at a Utopian position where pictures are made on a production-line basis has influenced historical trends in motion-picture set lighting. Some of these shifts have been responsible for major improvements in picture quality, while others, which were based on supposed economic gains alone, have often forced compromises with dramatic effect to the serious detriment of the finished product.[2,30,31,34]

A close duplication of production items in a manufacturing process may result from strict adherence to engineering principles. And it is not to be denied that when it becomes necessary to deviate from engineering formulas, the one who does so with a complete understanding of what he is doing has an advantage over the empirical worker. Nevertheless, the one who works largely on a trial-and-error basis often produces a more successful motion picture if he keeps his thoughts on the emotional end result. This often requires a departure from strictly engineering efficiency in order that the production may be the same as the previous like group, but will provide a seemingly fresh presentation. An engineer who defends a position of strict adherence to basic engineering principles, regardless of the boxoffice value of the finished product, on the basis that he is an engineer and not an artist, is doing a bit of rationalization.

The film technician may desire a negative showing some detail in all shadow and highlight areas with most of the density range on the straight-line portion of the gamma curve. It is this desire for his own limited goal that has often encouraged him to extol the merits of flat light. The art director may desire sufficient overall density to insure an appreciation of the beauty of his set. But the director and cinematographer may be striving for a dramatic effect that fails to meet the desired requirements of either film technician or art director, yet does achieve the end result in that particular shot of affecting the senses of the theater patron in a manner which will forward the total desired effect of the story.[9,10,15,16,19,21,22,23,29]

In the beginning, little thought was given to anything except a sufficient amount of light to provide exposure. Novelty effect took the place of dramatic effect. The motion picture was a magic lantern with movement, "just a passing fancy."

It is true that as early as the turn of the century, Thomas Edison built an experimental motion-picture stage which was mounted on a turntable so it could be rotated to follow the changing relative location of the sun. The infant industry, however, was in no position to try any costly experiments. As a matter of fact, where the cameraman helped to write the script, build the sets and even double in brass for all types of production work, there was little time for artistic expression.

Fortunately, as the motion-picture industry began to expand, there was a considerable number of people who saw the possibilities of the medium as a means for dramatic effect and the cameraman was one of the major leaders toward creating dramatic results that would entertain people by affecting them emotionally.

At that time in motion-picture production, sunlight was the only available light source and sets were photographed on open stages with muslin diffusers mounted on wires so they could be adjusted to control the light. Various types of reflectors were also used to redirect the rays from the sun and avoid heavy shadows on the faces of the characters and throughout the set. A wide assortment of translucent and opaque objects are still in general use to diffuse and control light (Fig. 1).

Because pictures were made in black-and-white, the question of color quality was not so important as it is today. However, the cameraman was handicapped by wide variations in intensity and position of his sunlight source throughout the day, and during inclement weather he was unable to work at all.

As a natural outgrowth of this situation, glass stages similar to large greenhouses were constructed and diffusers were installed as on the open stages. The reason for the glass stage was to permit the picture companies to operate during inclement weather; however, the advent of artificial lighting at about the same period made them obsolete and they were seldom used in the manner for which they were originally designed. The advantages of working under artificial light were so great that most of the sets built inside of the glass stages were covered over with canvas, or other means were employed to exclude the natural light. Later, the glass panels were painted black so the natural light could not interfere with the

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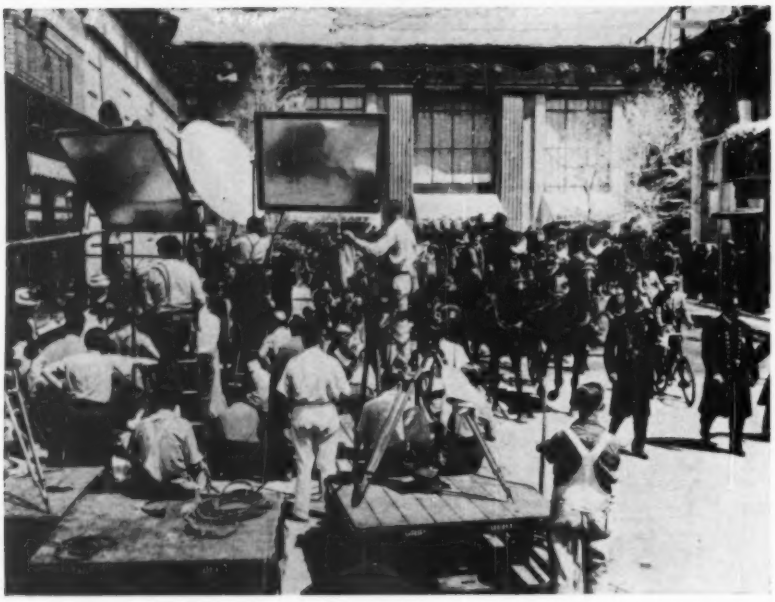

Fig. 1. A Paramount picture photographed in 1939. Sunlight is the light source. Note the use of reflectors and circular scrim protecting some of the principals from overly strong shadow effects. Street set is rigged with canvas roof that may be pulled over to make closed set if artificial light is used.

controllable artificial illumination being used.[26]

In the earlier serious attempts at set lighting the cameraman worked with old-type, street-lighting carbon arcs and banks of Cooper-Hewitt mercury tubes placed directly overhead and at angles in an attempt to obtain a flat, diffused light all over the set. Cooper-Hewitt mercury lamps were installed in the Biograph Studios, New York, as early as 1905. Overall exposure requirements, lack of adequate equipment and economics made anything but flat lighting difficult, if not impossible, to attain.

It was known by the cameramen that added interest, improved perspective, increased illusion of depth and much greater dramatic effect would be obtained if they could skillfully utilize powerful light sources that would give them the effect of a one-source lighting such as could be obtained from the sun under ideal conditions, but the industry had not yet attained the position where such specialized equipment could be properly designed and made.

The time finally arrived when the public had accepted the silent pictures and fortunes were being made in production. This brought competition, which in turn opened the door for the cameraman to take some chances, to try anything he could get his hands on, to use his creative ability without fear of sudden replacement by a penny-wise management. In 1912, white flame carbon arcs replaced the low-intensity enclosed arcs at Biograph.

One of the cameraman's first demands was for a controllable light source that would give him twice the power and twice the penetration capacity of anything he had. His only source of equipment was to follow precedent and adapt from other fields as had been done with the street-lighting carbon arcs and the Cooper-Hewitt mercury banks.

Carbon-arc floodlamps, better adapted to floor lighting than the other equipment, were obtained from the graphic-arts and still-photographic fields (Fig. 2). Carbon-arc spotlamps were purchased from the theater-projection and stage-lighting fields. Such lighting equipment companies as M. J. Wohl & Co. and Kliegl Bros., of New York, turned their attention to motion-picture studio lighting equipment. It was from the name Kliegl that the "Klieg-light" originated. Even the military searchlight was adapted for use where a greater amount of light was needed (Fig. 3).

Later, various adaptations of these units were built, or assembled by newly formed lighting companies in Hollywood. Among these concerns were Winfield-Kerner, a manufacturer of lamps for the graphic-arts trade, Creco Co. and Cinema Studio Supply Co., started by people from within the motion-picture industry.

The status of the cameraman improved with his increased ability, from both the equipment and economic angle, to show what could be done with light and his title was changed to Cinematographer, or Director of Photography.

To obtain dramatic effect, the cinematographer has always been forced to compromise with engineering efficiency. The only time he would ever, or will ever, compromise with dramatic effect is under economic pressure that he cannot control. The equipment he searched for was something that provided a wide latitude of utilization even at the sacrifice of overall efficiency from the light-output, or power-consumption, viewpoints.[32]

Because they could be placed where the carbon arc could not, and because they provided a soft, more or less non-directional source of light, the cinematographer often tried to use incandescent tungsten bulbs for certain effects. His efforts in this direction were largely frustrated at the time because of the low speed and limited color sensitivity of the film then used. The preponderance of light from the tungsten bulb is in the red end of the spectrum and his film was blind to red.[13]

Color motion pictures were not a major factor in those days, but color rendition in shades of gray of the same saturation as seen by the eye when looking at the original was something the cinematographers needed badly. Even a reasonably light-red object would photograph black. The advent of panchromatic film gave the cinematographer a better control of his gray scale and also made it possible for him to start experimenting with incandescent tungsten bulbs.

In spite of equipment that was ill-

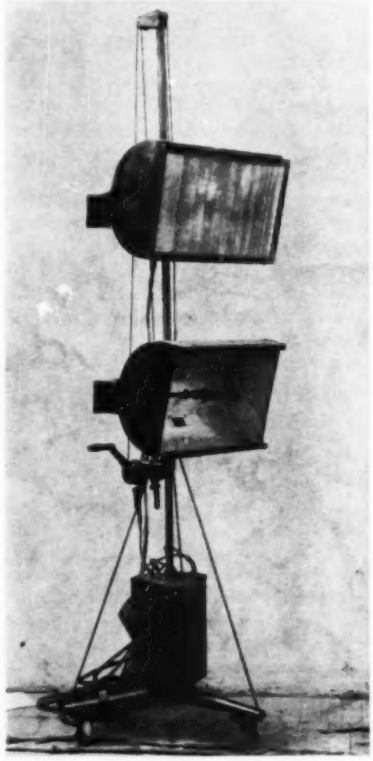

Fig. 2. An early type of solenoid feed carbon-arc floodlamp.

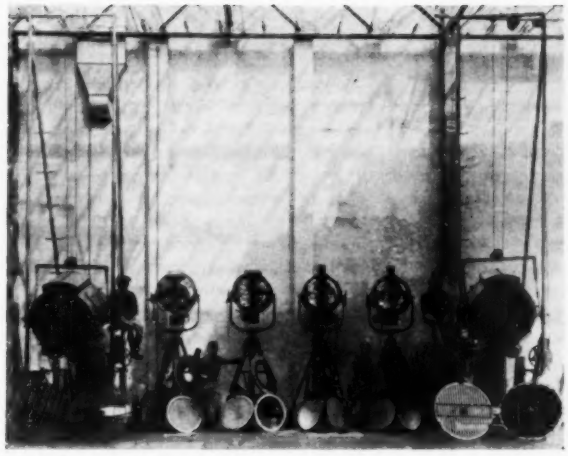

Fig. 3. Sunlight arc lamps — 24-in. and 36-in. — popular during the 1920's and early 1930's. This equipment was adapted from the military searchlight.

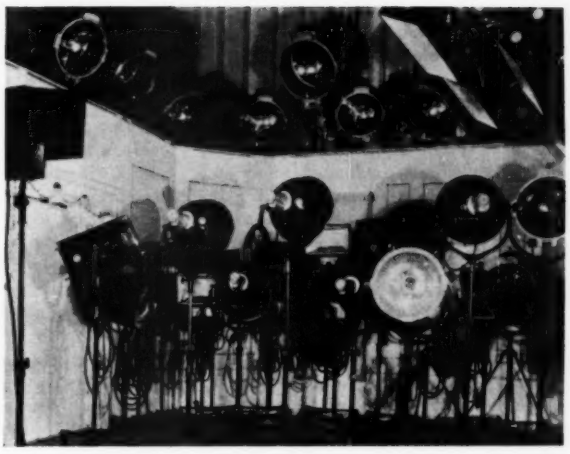

Fig. 4. Grouping of incandescent tungsten lamp equipment of the types more popular in the late 1920's and early 1930's with some still in use.

adapted and inefficient, the cinematographer was beginning to achieve an art form when the advent of sound in 1927 imprisoned his cameras in static, awkward, soundproofed booths. The importance of the new sound medium transcended all demands for photographic quality and the cinematographer was forced to reduce his art to a mechanical function in order that an acceptable, audible result might be obtained.

Restricted to small sets and with his camera static, the cinematographer began to experiment with fresh approaches to his goal of photographic dramatic effect. Soon a number of cameras were running on the same set in order to achieve the effect of movement, and the cinematographer began casting about for light sources that would not be restricted, as were his cameras, by the noise they created.[3–9]

He had been experimenting with panchromatic film which was not blind to the red light, and in the incandescent tungsten bulb he saw a lighting medium with which he could obtain soft effects and which he could use for base lighting.

It was in 1927 that the Mole-Richardson Co., of Hollywood, was formed to manufacture, sell and rent all types of specialized studio-lighting equipment. This firm now operates all over the world wherever motion pictures are made and has provided many versatile lighting tools exclusively for motion-picture set lighting. Another firm established at a somewhat later date was the Bardwell & McAlister Co., of Hollywood.

Some people in studio management saw in the incandescent bulb a means of economic gain whereby set lighting would be accomplished by a push of a button. They put all of their publicity efforts behind an incandescent-bulb campaign and for a time the carbon arc was virtually discarded, with orders in some places that it could be used only by special permission from the management.

Fortunately the novelty and value of added sound helped to overcome the photographic deficiencies of the period which followed. Camera lenses were not corrected for the red end of the spectrum and focus problems were legion. Sufficient incandescent-bulb equipment was not immediately available and certain motion pictures took on a dark, soft-focus appearance that was highly touted as the "new look" of the day. The pressure against the use of the supplementary carbon-arc lamps for sunlight, streaklight and other of the depth- and drama-producing effects was not only unfair to the efforts of the cinematographer, but to the value of the incandescent bulb itself. Partly as a result of this, many pictures were made where scope was limited to the techniques of the legitimate stage.

The sudden demand for housings to utilize incandescent tungsten bulbs resulted in adapting equipment from other fields and in the manufacturers imitating some of the carbon-arc lamp housings that had proven useful.

But as sound was absorbed into the industry, the cinematographer was again recognized as a creative artist. His immediate demands were for a lamp with twice the light and twice the penetrating power of anything available from the existing incandescent tungsten bulbs.

A rifled glass reflector, which had been used for incandescent tungsten flood-lighting at a distance from the source, was used as a basis for this demand for twice the light and twice the penetrating power.[25] From a light collecting and distribution standpoint it was particularly well engineered; from a utilization standpoint it was not flexible (Fig. 4). What the cinematographer wanted was a light with twice the intensity, twice the penetrating power and one that could be used at varying distances with control of beam spread and light distribution.

Of course the demand was fantastic! In order to give the cinematographer what he wanted, it would be necessary to sacrifice engineering efficiency all the way along the line. It would mean more powerful incandescent bulbs, bulkier equipment and higher operating costs. What had to be learned was that the efficiency of utilization was the all-important factor and that strictly engineering or tight-drawn economic factors must be made to compromise.

Compromises were made. Ten-kw bulbs were produced and even a 50-kw bulb was tried. The equipment became more flexible. Compromises were also made by the sound departments. Carbon-arc lamps, now filtered with electrolytic capacitors to reduce generator ripple, again appeared on sets where the effects of sunlight, streaklight and back-

Fig. 5. Stepped-prism, Fresnel-type lens introduced in 1934. Controllable beam spread of from 8° to 48°. Introduced to the motion-picture industry by Mole-Richardson Co., Hollywood.

light would allow the cinematographer to express his individuality and to produce the illusion for which he was striving.[11,24]

It was this era that marked the first of the major changes made by manufacturers of studio-lighting equipment to provide units with maximum power and maximum utilization. Specialized incandescent bulbs were produced to replace those which had been adapted from other fields. In 1934, lamps with large-diameter, mirror-type optical systems were replaced with stepped-prism condensers made along the lines of the well-known Fresnel lens system (Figs. 5, 6 and 7). It appeared as though the industry was settling down to a lighting technique in which the incandescent bulb and the carbon arc were lighting tools available to the cinematographer depending upon his own interpretation of his artistic needs.

The one exception was the clarion cry, "I want a lamp with twice the light and twice the penetrating power!" But in the entertainment field, standardization of techniques often result in formula without novelty or apparent difference. It is quite true that people want formula, that they will not accept anything which does not carry a familiar connotation. They will pay money to see the same thing they saw last week or last year. They want it to be the same, but they want it to be *differently the same*.[27]

The first major revolution was in the advent of sound. Now color stepped in for a go at it!

Technicolor, who had been struggling with a two-color process, announced that they were ready to launch motion pictures in the full color scale and that the white light of the carbon-arc lamp would be needed for the process.[17]

The announcement by Technicolor did not produce chaos in the industry as had the arrival of sound, because the studio people believed that color was something they could take or leave alone. Many believed that color would never replace black-and-white and others reasoned, correctly, that if it did eventually replace black-and-white it would be by evolution and not by revolution.

The advent of *Becky Sharp*, Technicolor's first major three-color release in 1935, did cause a revolution in the studio-lighting field. The carbon-arc lamp was again to be the predominant studio-light source and the unbalanced spectrum and comparatively low light output from a single unit of the incandescent bulb made its future appear quite bleak to many observers.[10–15]

Some work had been done on the design of a new type of carbon-arc spotlamp and these were hurried into production. For floodlighting, an adaptation of the older carbon-arc floodlamps was made and later a completely new design was manufactured and replaced the earlier units.[18] It was the heyday for the carbon arc. It would be necessary to throw away more than half of the energy from the incandescent lamp to make it match white light, so to all intents and purposes it was through insofar as use on color sets was concerned.[12]

But the cinematographer missed the soft diffusion, the small overall equipment size and the fill-light quality he obtained from the incandescent lamp almost as much as he had missed the small source size and great power from one unit of the carbon arc in the early days of sound; so color filters were made and incandescent lamps found their proper niche in Technicolor photography even though the film sensitivity did not indicate their use as an economic value.

Until the introduction of three-color photography, the photographic exposure meter was not used to any extent in the motion-picture studios. The cinematographer lighted his sets by visual judgment and depended upon photographic exposure tests when in doubt. Some worked almost entirely from their interpretation of a dramatic effect and refused to compromise with certain basic engineering demands, with the result that there was a constant feud with the developing laboratories over who did what with which.[19,21]

The more restricted latitude, and even the handling of color itself, made it necessary to apply greater engineering efficiency to motion-picture photography in order to obtain added dramatic effect which color itself could provide. For the successful introduction of three-color, motion-picture photography, Technicolor found it necessary to demand certain engineering requirements so that the finished product would provide this dramatic effect.

In order to accomplish this result they supplied their own technicians to operate the three-strip cameras and contracted with a number of successful cinematographers to supervise the set lighting. As soon as possible, all cinematographers were made familiar with color requirements, one of which was the accurate control of light.[14–16,22] The cinematographer still does much of his light balancing by visual means, but he also reads the incident light in various areas and when he goes beyond the latitude of the system in order to obtain a certain dramatic effect he has been forewarned.

One of the major advances made by Technicolor was the announcement that they had doubled the photographic speed of the system. When the cinematographer was asked if this would bring about the use of smaller units, the response was that much of it would be used for increased depth of focus and greater latitude of operation. What was wanted was a light source with twice the penetrating power of existing lamps. A new super high-intensity, carbon-arc lamp was designed to fill this demand.

It should be noted that the first change from a preponderance of carbon arcs to a preponderance of incandescent bulbs was made possible through a change in film sensitivity. The next revolution in

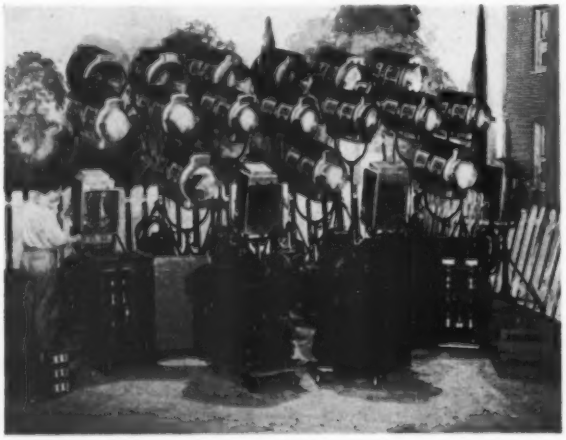

Fig. 6. Modern carbon-arc lamp equipment.

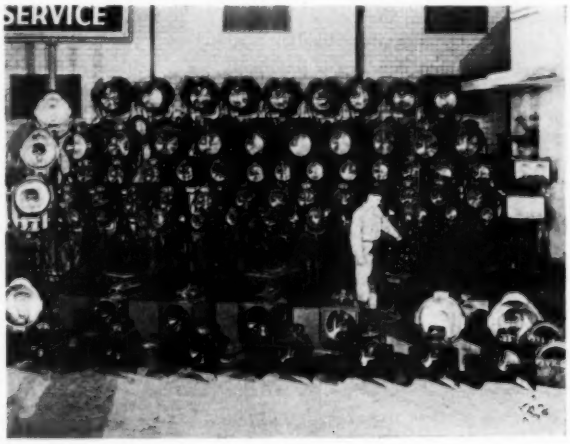

Fig. 7. Modern incandescent tungsten lamp equipment.

lighting was the result of the film sensitivity of the new Technicolor process. In each case one type of light source was almost superseded by the other, until management pressure was relaxed giving the cinematographer a chance to fit the units in where they could be used for the greatest dramatic effect.

The next revolution came during 1950 when, due to loss of revenue, the carbon arc, because of manpower requirements, was singled out as the heavy in the melodrama of economics versus production values.

Technicolor changed the basic sensitivity of its system to match the color temperature of the incandescent bulb so it could be used unfiltered with incandescent lamps, or filtered with sunlight or carbon arcs. Eastman and Ansco soon did likewise with their color films. If mixed lighting was to be used the incandescent tungsten lamps would have to be filtered to the temperature of the carbon arcs, or vice versa.[33] The changed film was faster to incandescent tungsten than to white light and it appeared as though a revolution had taken place which would give the cinematographer much greater latitude of operation.

On a small set, or where a preponderance of incandescent lamps was indicated, he could use them and filter whatever arcs he wished to use. On a large set, he would go on a white-light basis and filter what incandescent units he had, thus providing a possibility for more latitude of operation first, and added economy second. The man with the pocketbook did not agree with this logic. The system had been changed to match incandescent lamps and incandescent lamps it would be. One studio even announced the sale of carbon-arc equipment.

Higher-powered incandescent lamps were demanded, a lamp that would produce twice the light and twice the penetrating power. The result was a revival of 10-kw lamps adapted to optics improved beyond ones that had been tried before, plus the wide usage of the highest-powered, carbon-arc lamps filtered to the spectrum of the incandescent lamp.

An occasional cinematographer ventured color production on a white-light basis, but on the whole he remained with the tungsten balance because of so-called economics. He now wanted a lamp with the penetrating power and light output of twice that of the highest-powered, carbon-arc lamp, but with the color temperature of the incandescent lamp so he could use it on his sets freely mixed with incandescents and without the necessity of a lamp filter.

What he actually needs is more freedom of choice for the improvement of production values rather than for small economic squeezing which robs him of the initiative it takes to make something *differently the same*.

Now comes the revolution of 3-D and wide screen with requirements of smaller lens apertures, much larger sets and the extreme in production values. As always, more light, the maximum of latitude of operation, and the extreme in creative ability will be needed. If history repeats itself, as the pendulum swings toward fewer and better pictures, the choice of set-lighting equipment will again revert to the man who directs the use of it and he will be casting about for a controllable light source with twice the light output and twice the penetrating power of any existing equipment, whether it be incandescent tungsten, carbon arcs, or some other form of radiant energy.

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History of Professional Black-and-White Motion-Picture Film

By C. E. KENNETH MEES

Beginning with the regular roll film emulsion-coated on a length of clear support, which was sent to Mr. Edison for his first experiments, there have been many changes and improvements in the negative motion-picture films and the addition of positive films, sound-recording films and other special films which have themselves been improved from time to time, resulting in improved techniques and better motion pictures.

THE PRODUCTION of motion pictures involves a combination of the theatrical art and photographic technique, and its history has depended upon the development both of the theater and of photography. I have been asked to give you an account of the development of the films used in making motion pictures, and in doing so I must call attention to the close relation between the methods used in the production of pictures and the nature of the films which have been available.

This account deals only with the films manufactured by the Eastman Kodak Co., a record of which was available to me. A number of other manufacturers have played an active part in the development of the industry and have made a variety of films. The Lumière Co., of Lyons, France, made film at a very early date in connection with the development of motion pictures by Auguste and Louis Lumière and later sold a considerable quantity of motion-picture film to American users.

In 1918 the Du Pont Co. commenced the manufacture of motion-picture positive film and have since made a range of films for motion-picture purposes. The Agfa-Ansco Co. manufactured motion-picture positive film, and their successors, the Ansco Division of the General Aniline and Film Co., have been active in the supply of film to the industry.

This account of the development of motion-picture films deals only with the films which produce monochrome images.

The beginning of motion-picture production in the United States was associated with the first production of transparent film, made for use in Kodak cameras. In 1887, W. K. L. Dickson was working in Edison's laboratory in West Orange on an instrument to be used with the Edison phonograph to reproduce motion as well as sound. In this instrument, very small images were photographed in a continuous spiral on a cylinder, as sound is recorded on the phonograph cylinder. In September 1889, however, Dickson sent an order and $2.50 to George Eastman for a roll of film 35 mm in width. This film was used in a new type of kinetoscope for taking motion pictures on a continuous strip of film which was standardized at a width of $1\frac{3}{8}$ in. with four perforations to a frame along both edges, the film which, in essence, is that used today.

The emulsion was that used in the Kodak cameras and at first this film was used for making both negatives and prints, but in a very short time a special film was made for positive prints. It gave more contrasty and brighter prints, and, being of lower speed than the camera film, it was easier to handle in printing.

In 1916, when the Society of Motion Picture Engineers was formed, only two motion-picture films were available—a negative film for use in the camera and a positive film for making prints. The negative film was sensitive to blue, violet and ultraviolet light, and it was necessary to expose it outdoors by daylight or in studios by the use of arc lamps. Thus motion-picture studios found California, with its abundant sunshine, a convenient location, and a number of excellent lighting units using arc lamps were developed, at first to supplement and later to replace sunlight.

In January 1917, a change was made in the basic emulsion of the negative film which was known simply as "motion-picture negative film" until, owing to the introduction of other films in August 1925, its name became Motion-Picture Negative Film Par Speed. As new films were introduced, it became necessary to use some identification for the type of film other than rather indefinite names, and the Eastman Kodak Co. adopted the practice of assigning type numbers to the films, using new numbers not only for new kinds of films but for new varieties of the same kind, the old type being continued on the market for the convenience of customers until it was effectively replaced by the new introduction. The type numbers constituted to some extent a code. Thus 1 indicated a film on nitrate base; 2 in the second place indicated a negative film. Par Speed negative film was therefore assigned Type 1201, and its emulsion continued essentially unchanged until it was discontinued in July 1942.

Panchromatic Negative Materials

As early as 1913, experiments were being made at Rochester on the production of a panchromatic negative film. The first panchromatic film was made for use in the Gaumont process, an additive process of color cinematography in which negatives were made simultaneously through three lenses equipped with suitable filters, and the pictures were projected in register by a three-lens system. This process was introduced by Léon Gaumont in France, and Mr. Eastman decided to consider its introduction upon the American market. Gaumont made his panchromatic film by bathing negative film in dye solutions, but this process is very prone to give spots and other defects, and experience with the Wratten panchromatic plates had shown that there was no great difficulty in sensitizing an emulsion to make it panchromatic. The real difficulties lay in the conditions necessary for coating the emulsion. Much credit is due to the workmen and supervision who succeeded in coating the panchromatic film in those early days. The operatives were accustomed to red light in the coating rooms, and it was not easy to work in almost total darkness.

Panchromatic film was originally supplied in small quantities as experimental material. Some of this was used as early as 1919 by Charles Rosher. In 1923 it became a regular product of the Eastman Kodak Co. One of the first, if not the first, regular productions made on panchromatic negative film was *The Headless Horseman*. The cameraman was Ned Van Buren. It was photographed in 1922, and the negative is now in the vaults of Eastman House in Rochester, N.Y.

The panchromatic film was at first higher priced than the blue-sensitive film, but in 1926 the price of the panchromatic film was lowered to that of the Par Speed Negative Film, and its sale began to increase rapidly. In 1928 the film was assigned Type 1203, and the name Motion-Picture Negative Panchromatic Type I was given to it.

In 1926 L. A. Jones and J. I. Crabtree published, in the Transactions of the Society of Motion Picture Engineers, a paper on "Panchromatic Negative Film

Presented on May 3, 1954, at the Society's Convention at Washington, D.C., by C. E. Kenneth Mees, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.
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for Motion Pictures," in which they summarized the properties of panchromatic film, its use with various light sources, the reproduction of colored objects obtained by its use and its handling in the darkroom. The use of infrared-sensitive film was also discussed and illustrated. The first infrared negative film was introduced under the name Panchromatic K in 1928 as Type 1210. Infrared film renders blue skies as black, and green foliage as white, and is used chiefly for the simulation of night effects in pictures taken by sunlight. Very great improvements have been made from time to time in the sensitizing of infrared film.

The use of panchromatic film became general in the studios by 1927, and tungsten light was being used to an increasing extent instead of arc lamps, especially for supplementary lighting. In 1928 the Du Pont Company put panchromatic film on the market, and the Kodak Company introduced Cine Negative Panchromatic Type II, Type 1218, which continued on the market until 1935. The year 1928 was, as we shall see later, one of great activity in the production of new types of motion-picture films.

Sensitizing Dyes

At this point, it is necessary to say something of the development of sensitizing dyes. Up to 1928, the dyes used for photographic film were those which had been developed by E. Koenig and his colleagues and which had been introduced by the German dye company, Farbwerke Hoechst. All these dyes were derived from quinoline. The green sensitizers were isocyanines; the red sensitizer generally used was pinacyanol, a dye made by the same reaction as the isocyanines, with the addition of formaldehyde. This reaction had been discovered by B. Homolka. Curiously enough, the chemical structure of pinacyanol was unknown or, if its originators knew its structure, they didn't publish it. During the First World War, sensitizers having the same structure and properties as the German dyes were made both in England and in the United States, and a study of the chemical structure of the dyes, and especially of pinacyanol, was carried out by W. H. Mills and W. J. Pope at Cambridge University. As a result of this work and of its extension by Mills and his pupils, it became evident to dye chemists that cyanine dyes similar in general structure to the German dyes could be made from a great number of organic compounds other than quinoline, and that a vast number of these dyes must exist. Starting in 1928, therefore, the laboratories of the photographic manufacturers in England, Germany and the United States began to produce new sensitizing dyes at a very rapid rate. A summary of the work in the Kodak laboratories alone can be given by saying that since the beginning of 1930 the sensitizer laboratory has on the average produced one new sensitizing dye a day. The use of these new dyes, and especially their use in combinations, made possible a great increase in the color sensitivity of photographic materials.

In 1931 Super-sensitive Cine Negative Panchromatic Film was introduced as Type 1217 and rapidly displaced the 1218 panchromatic film which had been the standard Eastman material for negative making in Hollywood. A faster film known as Type 1227 was made in 1935. This was named Super-X Panchromatic Negative Film. It had a new basic emulsion with ortho-panchromatic sensitizing. It had a comparatively short life, however, because in 1938 a group of new films was introduced characterized by appreciably higher speed and lower graininess. They were made possible by basic developments in emulsion making which affected practically all high-speed films. The new motion-picture negative films were Type 1230, Background X Panchromatic; 1231, Plus-X Panchromatic; 1232, Super-XX Panchromatic. Of these, Type 1231 quickly became the most popular motion-picture camera film made by the Eastman Kodak Co. It is currently in production and is still our largest-volume camera film. Type 1232 was similar to 1231 except that its emulsion was appreciably faster and coarser in grain. It was the fastest Kodak film made at that date and is still a current product, though the recently introduced Tri-X Negative Film Type 5233 will probably take its place.

Special reference should be made to 1230, the Background X Cine Negative Panchromatic. This film was a successor to films introduced in 1932 for making background shots. Type 1212, a panchromatic emulsion of medium speed and finer grain than the 1217 negative panchromatic film of that date, was replaced a year or two later by Type 1213, and in 1938 Type 1230 largely replaced 1213.

Release-Print Positive

Now let us turn from the negative-making material to the release-print positive, of which such very large amounts have always been used in the motion-picture industry. The positive film has two characteristics in which it differs from the negative material. It must be of sufficiently fine grain to increase to the smallest possible degree the graininess inherent in the negative. It must also have a contrast which, when combined with that of the negative material, will give a satisfactory contrast in the projection print. Using as a measure of contrast the slope of the straight-line portion of the characteristic curve, Hurter and Driffield's γ, experience has shown that the projection print should have an overall γ of approximately 1.3. The exact reproduction of the tone scale of the original would, of course, require a γ of 1.0, but loss of contrast owing to light scattering, and so forth, requires a somewhat higher γ than 1.0 for the best tone rendering. To obtain the required overall γ with a minimum of graininess, it has been found advisable to develop the negative material to a γ of 0.65, so that the positive material must have a γ of approximately 2.0. Thus the positive material should have the finest possible grain, should give a γ of 2.0 at convenient times of development and, at the same time, must have sufficient speed for printing in the standard motion-picture printers. The positive emulsion supplied as Eastman Cine Positive Film in 1916 met these requirements satisfactorily and remained unchanged for many years. When type numbers were introduced, it was assigned Type 1301.

Many attempts were made to produce a positive film having a lower graininess, but all failed because the film was too slow for use on the standard printers and also tended to give a warm-toned image, which was not generally satisfactory for projection. It was not until 1940 that Fine-Grain Release Positive Type 1302 was made having sufficient speed, provided that the printers were modified to increase the light available, and having definitely lower graininess than Type 1301 with an image of pleasing tone. Types 1301 and 1302, therefore, cover the whole history of motion-picture positive film up to date.

Colored Bases for Tints

About 1920 a demand arose for positive films on colored base, which enabled a tinted film to be obtained by simply printing upon film having the right color in the base. In 1921 positive films were available on lavender, red, green, blue, pink, light amber, yellow, orange and dark amber bases. When by 1929 sound films had displaced the silent films, difficulty arose with the tinted bases because the dye absorbed the light used for exciting the photoelectric cells by which the sound record was reproduced. A new range of tinted positive supports were therefore introduced under the name of Sonochrome. They were designed to provide satisfactory monochromatic scenes and, at the same time, enable the sound record to be utilized without difficulty in projection. They were described by L. A. Jones in a paper in the Transactions of the Society. After the fine-grain cine positive was in-

troduced in 1940, three of the Sonochrome tints were used for this new emulsion.

In 1926, J. G. Capstaff and M. W. Seymour published an important paper in the Transactions of the Society on the duplication of motion-picture negatives. At that time, prints made from duplicate negatives were notably inferior to direct prints. Duplicate negatives were usually made on Par Speed Negative material from projection positives and showed graininess, distorted tone scale and edge effects. A new duplicating film was made by the use of a fine-grained emulsion, the contrast of which was controlled by the addition of a water-soluble yellow dye. It gave little increase of graininess, good tone rendering and a minimum of edge effects, because development could be prolonged to eliminate the effects without producing too much contrast. At first, the same film, Type 1503, was used for both negative and positive.

In 1929 a duplicating positive, Type 1355, was introduced. Its speed was somewhat higher and its contrast somewhat lower than the standard release-print material of that date. In 1930 a fast, yellow-dyed negative material was coated as Type 1510. In 1933 a duplicating positive Type 1362 was introduced; in 1936 two new duplicating films were made having a finer grain than the regular positive of that date. These were 1203, Fine Grain Duplicating Negative Panchromatic, and 1365, Fine Grain Duplicating Positive.

Films for Sound

When the motion-picture trade adopted the reproduction of sound, interest arose in the use of special films for sound recording. There were two different methods of recording sound upon film: (1) that in which the density of the track was modulated, the variable-density method; and (2) that in which the width of the track was modified, the variable-width method. In 1930 L. A. Jones and O. Sandvik published a discussion of the "Photographic Characteristics of Sound Recording Film" in the *Journal* of the Society. The variable-width recording method did not present a serious problem since release positive film gave very good results, but in 1928 a yellow-dyed, negative-type emulsion was introduced as Type 1507 for use in variable-density sound recording. Not until 1932, however, was a sound-recording film, Type 1359, supplied which gave results in variable-density sound recording sufficiently better than those obtained on motion-picture positive film for it to be generally adopted by the trade. In 1936 Type 1357 was introduced for variable-area recording. Types 1357 and 1359 were very similar, and new films, Type 1372 for variable-area and Type 1373 for variable-density recording, were introduced at approximately the same time in 1944 and are still in use.

Films specially made for color photography are dealt with in another paper, but it should be mentioned that since 1916 many films have been made for use in current processes of color photography. The Technicolor Corp., for instance, has used special red-sensitive, green-sensitive and blue-sensitive negative films in its three-strip cameras. It has also used specially made matrix films and positive films on which the final image was built up by transfer printing. Many of these films have been made to the specifications of the Technicolor Corp., and their development is a part of the history of the Technicolor process.

Bipack film for taking negatives by means of red and green light, Type 1208, was made first in 1930. It was a fast emulsion, green-sensitized with one of the first of the modern sensitizers and overcoated with an orange-red dye. It was exposed through the back in contact with a panchromatic film, so that the green negative was made upon Type 1208 and the red record was made on panchromatic film. A blue-sensitive film overcoated with a red filter dye was introduced as Type 1239 in 1938. This could be used in contact with a red-sensitive film to give the blue record in a three-strip system. For printing two-color negatives, yellow-dyed positive film single- and double-coated had been introduced in 1923, the single-coated material being used for the then current Technicolor process, and the double-coated film, for the Prizma process of color photography. Although the Prizma process had a short life, the duplitized, yellow-dyed, cine positive Type 1509 is still in production. It has been used in many color processes employing two-color systems.

Safety Base Films

Ever since 1909, efforts have been made to replace the highly inflammable cellulose nitrate base of motion-picture films by a cellulose acetate base. The earlier acetate films were unsatisfactory as regards their physical properties. They retained more solvent than nitrate film and as this solvent evaporated they shrank, until finally they might not fit the sprockets. The shrinkage also manifested itself as cockle and curl. Nevertheless, safety positive film was made in appreciable quantities before 1916 and has been made ever since. It was absolutely necessary for projectors used without a booth. Safety film, as will be seen later, also played a great part in the development of the 16mm program. Improvements in the acetate base were continuous until 1950, when a marked change was made by the adoption of triacetate base. Cellulose triacetate gives much improved physical qualities to the base, compared with the earlier material which contains slightly less acetyl in the structure of the molecules. As a result, the triacetate base proved to be as suitable as the earlier nitrate base. In 1950 nitrate base was discontinued, and from the beginning of 1951 all film has been made on the safety triacetate base. Since 1928, safety film has been distinguished by the substitution of Type 5 for 1 as the initial number. Thus Plus-X Panchromatic Negative is now known as Type 5231 and Fine Grain Release Positive as Type 5302.

The first 16mm film was introduced in 1923 as part of a program of home cinematography. An orthochromatic film, Type 5204, was first manufactured in May 1923 under the name of Kodak Safety Film for the Cine-Kodak and other cameras using 16mm film. This film, after exposure in the camera, was from the beginning developed by a reversal process to a positive and used as a final print for projection. It was this system which was responsible for the success of the 16mm program which has had such wide application in the whole development of motion pictures.

Panchromatic Cine-Kodak Film, Type 5255, was placed on the market in 1928. The camera film was first supplied for daylight loading with a paper leader. Many experiments were made on the use of an opaque backing to avoid the troubles involved in the use of the paper leader. Finally, in 1931, a jet-black backing was made which gave the necessary protection to the film and which was removed in the processing machines. Supersensitive Cine-Kodak Panchromatic Type 5256 was introduced early in 1931, and this was replaced in 1939 by Super-X Cine-Kodak Panchromatic Film having the same type number, 5256, which is a current product. In 1938 Super-XX Cine-Kodak Panchromatic Film, Type 5261, supplied the need for an ultraspeed reversal film.

Undoubtedly, new black-and-white films for use in motion-picture photography will be introduced from time to time and will embody improvements made possible by the advance of the emulsion-maker's art. The future of motion-picture photography, however, involves the use of color, and the principal advances in motion-picture films will depend upon the improvement of the materials and processes used for color photography.

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The Production of Motion Pictures in Color, 1930–1954

By GERALD F. RACKETT

This paper presents a nontechnical exposition of the color film situation between 1930 and 1954. The relation of color to professional feature entertainment motion pictures and the part that color cinematography plays in the construction and reproduction of such pictures are described.

1930 saw the rapid decline of two-color photography for professional feature entertainment pictures and the realization by forward-looking color technicians and business administrators that full three-color rendition would be required if color were to become an important attribute of feature pictures. However, it was not until 1954 that the last regularly available service in Hollywood for two-color release prints of feature pictures was permanently shut down. It was also 1954 that saw the most ambitious program of color in feature length entertainment motion pictures with more than half of Hollywood's product in the color medium. And it was also 1954 that saw the availability of several satisfactory processes, not only from commercial laboratories but from studio laboratories as well. Thus, the period 1930 to 1954 was a stimulating period of development and learning in the field of color cinematography. Starting with a small group who were trained in the three-color medium in the early 1930's, almost the entire roster of Hollywood supervisors and directors of photography as well as laboratory and studio production personnel, have been trained and through experience have qualified in the color medium.

During this period, I have been closely associated with the commercial developments in color cinematography and have kept generally aware of the developments of cameras, emulsions and their application to the problems of photographing feature pictures. In preparing a review of this period, I have a preference for a general exposition of the subject rather than summaries, graphs and tabulations of technical data, all of which has been documented in the files of this Society and other technical groups. I would rather explore the development of color cinematography during this period and evaluate the contribution that it makes to the entertainment feature motion picture.

Presented on May 4, 1954, at the Society's Convention at Washington, D.C. It was read by Emery Huse for the author, Gerald F. Rackett, Color Film Director for Columbia Pictures Corp., 1438 N. Gower St., Hollywood 28, Calif.
(This paper was received on April 26, 1954.)

So, let us take a closer look at the average feature picture and see if we can separate its component parts to determine where our subject, color cinematography, finds its place. Now, if we accept that the feature picture is designed primarily to provide mass entertainment, it would be useful for our purpose to assign an average successful picture a value of 100 entertainment units and on this scale, rather than on a basis of the cost of the picture or the boxoffice return of the picture, to measure the contribution of color cinematography.

First, we must have a story for "the play's the thing." Then, we must have a guiding executive called "the producer" whose job is the overall coordination of the multitude of details that must flow into place to form the finished product. The producer must choose and employ a writer of just the proper capabilities to convert his story to a suitable screenplay. This is most important and frequently difficult. The producer must also select a director who can translate the story from language to the living reality of people who can tell the story. And then the producer and director, and sometimes the writer, select a cast who will breathe believable life into the script. Sets are designed, wardrobe is selected, locations are chosen, makeup, headdress, furnishings and many other physical details are created, assembled and made available at the right place, at the right time. During the preparation and assembly of these items, which constitute the physical mounting of a picture, the color treatment of the story is always in mind so that the creative work of the art director, the wardrobe designer, the selection of locations, etc., fall in their proper place in the color score of the picture. Unlike the musical score, which most frequently is written to suit the finished picture, the color score must be used as a guide in its construction. Since all of this comprises the visual appeal of the picture on the screen, they are important items of the color cinematography and one of the aspects of recording a picture with which the cinematographer must be familiar.

When all of this preparation work is finished, the picture is ready to "shoot." The producer now presents his play, but this would be to no avail if he did not record the sights and sounds to that they are preserved for others to see and hear. It is one of these two recording functions that comprises color cinematography.

Color's Entertainment Value

Let us list the items we have discussed and assign to each a share of the 100 entertainment units that might be appropriate in each case. Now, such a distribution of these units will vary between somewhat wide limits, particularly among the first five items, and to a lesser degree between the last two, depending upon the picture. In a musical, sound and cinematography will have increasing importance, probably at the expense of the story or book while color cinematography might detract from the stark reality of certain dramatic stories and hence may not be used at all. The important point is to try and place the role of color cinematography in the scale of entertainment units for an average picture. So, for the story, 30 units; the producer, 10; the director, 10; the writer, 10; the cast, 25; sets and other physical mountings, 3; sound, 4; and cinematography, 8.

I have discussed this allocation with a few experienced Hollywood producers who find no fault with it as an average.

The Director of Photography

Let us next examine how the cinematography is done. The director of photography, by training and experience, has an appreciation of line, form, perspective, composition and color in dynamic rather than the static presentation. He is of the creative type rather than of the technical type. Of course, he has a good technical background which enables him to deduce the requirements of exposure, contrast, depth of field and similar functions. He has acquired this background in most instances by experience, first as an assistant cameraman, then as an operative cameraman, then as a cinematographer on second units and action shots usually not involving stars or principal players. From here he may have moved into small picture assignments and by study and application developed into a full-fledged cinematographer capable of directing the photography of feature entertainment pictures. An average minimum time to move through these assignments is fifteen years. Of course, of the many men who start as camera assistants, only a very few finally qualify as directors of cinematography because

in addition to being photographers, they must develop other important qualities and capabilities. Such a man directs a group of men on the set or location comprising his immediate camera crew, the electrical crew and grip crew in addition to other people on whom he calls for adjustments of makeup, hairdress, wardrobe, sets, properties, etc.

In the vernacular of Hollywood, a cameraman depends a great deal on the head of his electrical crew, the "gaffer" and upon the gaffer's assistant, the "best boy." Usually a cameraman and a gaffer work as a team. The gaffer will rough in the lighting of a set or location and the cameraman will do the finishing touches. Now, the job of the electrical crew is to place the various lighting units in accordance with the cameraman's directions. The cameraman's problem is not only to get light where he wants it and of the proper quality, that is specular or diffuse light as may be required and of the right color and intensity, but he must avoid getting light in areas where he does not want it. Shadow quality is very important to good color cinematography and consequently it is as important to stop the light from reaching places where it is not wanted as it is to get it where it is required. For this purpose the cameraman calls on the head grip, his best boy and assistants who block the light off with go-bos, cutters, skrims, nets, fingers, dots, and other devices which contribute to the "painting with light" of a set. The cameraman may need a carpenter to make some adjustments in the set, or of a painter to paint down highlights or lift a shadow, or of a greensman to adjust plantings, and he is alert to see that makeups are just right, particularly on stars, and that hairdress, wardrobe and other details are as they should be. All of this implies a capacity to get along with many and varied types of people and to merit their cooperation and help.

Lighting the players, and particularly the stars, calls upon the cameraman's greatest skill, not only in portraying the characterizations and their moods but in the skill required to erase defects and blemishes which would mar the perfection which the motion-picture audience expects in the appearance of their stars. Some cameramen, and frequently their gaffers, become particularly expert in photographing certain stars and it is not uncommon for important stars to require the selection of a cameraman of their choice. Like cameramen, actors and actresses expand their talents with experience but with experience time passes and with time comes lines and blemishes and other defects which the cameraman must convert into charm and beauty rather than distraction.

Prior to 1930, one of the unusual skills which proficient cameramen had developed was an ability to appraise light quality and intensity with the unaided eye and this was the principal method they used in establishing exposure. This method worked moderately well for black-and-white, first, because black-and-white film had exposure latitude to tolerate substantial departures in exposure from the optimum level, and secondly, because the industry was still in an era where picture negative was developed by the so-called test method. In this method, two or three feet of each camera-exposed scene were removed from the negative prior to development and developed at a normal time. These strips were then examined and if the exposure seemed to be low, development time of the full scene was increased and if the exposure seemed to be high, development time was decreased to offset partially the departure of exposure level from that desired. Of course, this also changed contrast and tone rendition but the quality of motion-picture photography had not advanced to a point where these variables were unduly disturbing.

With the advent of sound, the more desirable time-and-temperature method of controlling picture negative developing was adopted which aimed to keep the processing contrast of both picture and sound negatives to a uniform desired level. This deprived the cameraman of the safety factor which he had enjoyed in the test method. Color films are designed to be processed at a fixed contrast level. At the same time, all color processes, and particularly those available in the early 1930's had a very limited exposure latitude. This limitation made it necessary for the cameraman to expose his scenes at the optimum exposure level. Variations in either direction carried a loss of quality in the pictures. It was recognized that the human eye was not capable of reliably performing this task and means of measuring light intensities on motion-picture sets were introduced. I think the first such actual use was with a Weston paddle-type illuminometer calibrated in foot-candles, on a color sequence photographed for an important feature in the mid thirties. The introduction of this device, which considerably preceded the now well-known exposure meter, caused some consternation among cameramen. They felt that their artistic prerogatives were being encroached upon, but when the newness began to wear off and exposure meters calibrated in photographic terms became available, cameramen soon learned that they were an aid which in no sense deprived them of their creative efforts. The introduction of the exposure meter for the control of light intensities was a preliminary necessity to the growth of color cinematography and is one of the important events in the period 1930 to 1954. Thus, instrumentation entered the field of art.

The color systems of the early 1930's required either special cameras or revisions of existing black-and-white cameras. In each instance there was added weight and bulk which decreased flexibility. Thus came the dawning of the first appetite from studio production men for a color system suitable for normal black-and-white 35mm cameras; such a system made its appearance in the mid thirties in the reversal-type single film color original.

Color and Stereoscopy

Stereoscopy in motion pictures had been seen as color anaglyphs in short subjects and there was speculation as to what the value of stereoscopy would be in entertainment motion pictures. Of course, the color anaglyph method was not applicable to a full color system and the special multi-film types of color cameras presented physical problems in the photography of stereoscopic images. It was, therefore, to be expected that when a single-film color stock became available, one of its first applications would be to stereoscopic motion pictures in color. Such a picture was made for an automobile manufacturer; it was set up as an exhibit at the New York World's Fair in 1939. This, I believe, was the first use of stereoscopic motion pictures in color using two projectors tied together and separating the images with polarizing filters. There was some evidence, however, in observing the spectators at this non-admission exhibition, that there were problems in observing pictures by this method and there apparently was the general feeling that this was not the ready solution to the problem for feature length pictures. As is well known, there was a rebirth of this type of exhibition in 1952 which gave rise to a succession of stereoscopic feature motion pictures both in black-and-white and color. But this rebirth seems to have largely run its course and apparently substantial refinement of the present methods will be required.

Meanwhile, the general quality of color processes and color films improved and along with it cinematography kept pace, producing fine examples of motion pictures in color.

A further substantial impetus was given to the expansion of color in motion pictures with the development by the film manufacturers of the direct negative-positive type of film which not only could be used in standard black-and-white cameras but from which satisfactory prints could be made by processing methods little more complicated than those required for black-and-white.

The Boxoffice

At intervals through the history of the motion-picture business, the boxoffice has suffered declines for one reason or

another. Certainly, the most recent, and very serious decline, was undoubtedly contributed to by the rapidly growing, widespread interest in a new form of entertainment—television. It is also reasonably certain that pictures with compelling appeal were not made in sufficient numbers to keep the public coming to motion-picture theaters. When a similar decline in boxoffice interest occurred in the late 1920's a technical innovation, sound, did much to bring people back to the motion-picture theaters. The recent decline in boxoffice attendance has been reversed largely by technical innovations. Cinerama brought its illusion of depth and peripheral vision, three-dimensional pictures had new emotional impact, CinemaScope, and now other technical embellishments of motion-picture presentation have all restimulated motion-picture attendance. It is probable that the maintenance of this attendance can only be accomplished with pictures that appeal to the public, but certainly technical innovations played an important part in rekindling the interest; and important among these technical innovations were new concepts of color cinematography; the medium had been in technical "status quo" for too long. The public has learned to expect a flow of technical innovations in most of their services. Each year they have the selection of new models of automobiles, washing machines, dishwashers, electric razors, transportation facilities; in fact, in the technologic age in which we live, gadgetry and gimmicks have become the handmaidens of salesmanship.

When the industry has tried and tested the many innovations of color cinematography, which are currently being presented, as well as others which are being developed, and the public has indicated their preference, it is not unlikely that there will be a semi-standardization of color cinematography at a new level of perfection for presenting motion pictures.

There would seem to be an important lesson in this and previous experiences in the fall and rise of boxoffice attendance, particularly when it is considered that the innovations which are currently popular are largely the applications of developments of many years ago, old enough, in fact, for most of the patents on them to have expired. How long will it take for public apathy again to develop when the new methods of presentation have become commonplace and what new improvements are in the offing in color cinematography which the industry should be developing to market in an orderly program to help maintain the boxoffice at profitable levels and forestall the next decline? Perhaps such planning should include some new form of stereophonic sound which will have a greater emotional stimulus than the methods recently tried, or a true space image in color occupying the general area of the stage in motion-picture theaters. There is no attempt here to predict how such nebulous ideas will be solved but there is every reason to believe that the technical planning of the industry should be given more specific direction so that when the next stimulus is required it will be ready, it will have been thoughtfully prepared and it will meet the requirement successfully. Color cinematography has come a considerable way from the small, garish, low-definition images of twenty-five years ago to images capable of contributing their share of entertainment units on 100-ft wide screens. Certainly, more effective and compelling improvements will be required during the next twenty-five years than have occurred in the last twenty-five years if motion pictures are to remain an important medium of mass entertainment.

Duo-Flash Photography

By C. C. ROCKWOOD
and RICHARD M. KUNIYUKI

A duo-flash equipment provides accurately timed, short-duration light flashes for double-exposure, time-motion studies. The present circuitry is intended for use in observing action occurring in the range of 0.3 to 300 msec.

Duo-flash equipment is intended for application in time-motion studies where photographic data must be obtained within a few minutes after the experiment. It provides two accurately timed, short-duration light flashes with adjustable time delays. Two such equipments are commonly used together to give quadruple exposure photographs. A practical limit to the number of such exposures on a single film is set by the ratio of reflectance of subject to reflectance of background. The duration of each light flash is very short compared to the time interval between flashes, so that effective stoppage of action is achieved. The present circuitry is intended for use in observing action ocurring in the range of 0.3 to 300 msec.

Presented on May 7, 1954, at the Society's Convention at Washington, D.C., by C. C. Rockwood and Richard M. Kuniyuki (who read the paper), Chicago Midway Laboratories, 6040 S. Greenwood Ave., Chicago 37.
(This paper was first received on Apr. 1, 1954, and in revised form on August 10, 1954.)

General Description

The equipment consists of two units, the flashtube unit and the delayed-trigger generator. The flashtube unit contains one General Electric FT-220 photoflash tube along with a high-voltage power supply, two energy-storage capacitors, and two spark gaps. The delayed-trigger generator provides the triggers that pulse the spark gaps to flash the photoflash tube. It contains its own regulated power supply to provide the necessary d-c voltages. The two units are interconnected by a signal cable. Each unit requires 115 v, 60-cycle a-c power.

To initiate action, a negative pulse is applied to the delayed-trigger unit at "pulse in." The equipment then provides two light flashes at individually adjustable time intervals after the negative input pulse. This delay is continuously adjustable with full-scale ranges of 300 msec, 30 msec, and 3 msec. Where tandem operation of the duo-flash sets is desired, the delayed-trigger unit of one supplies the negative initiating pulse required by the second.

The correct exposure of film will depend on: (1) the joule "loading" of the flashlamp; (2) the distance from the flashlamp to the subject; (3) the reflectance of the subject and the background; (4) the film speed; and (5) the camera *f*-stop. This exposure data is usually expressed as the "guide number" which is *f*-stop times distance in feet from lamp to subject. The proper guide number to use is determined experimentally. Since there is considerable latitude in the photographic process, a precise determination is not necessary and satisfactory results are obtained over a wide range. For example, using Super XX (ASA speed 100), with an

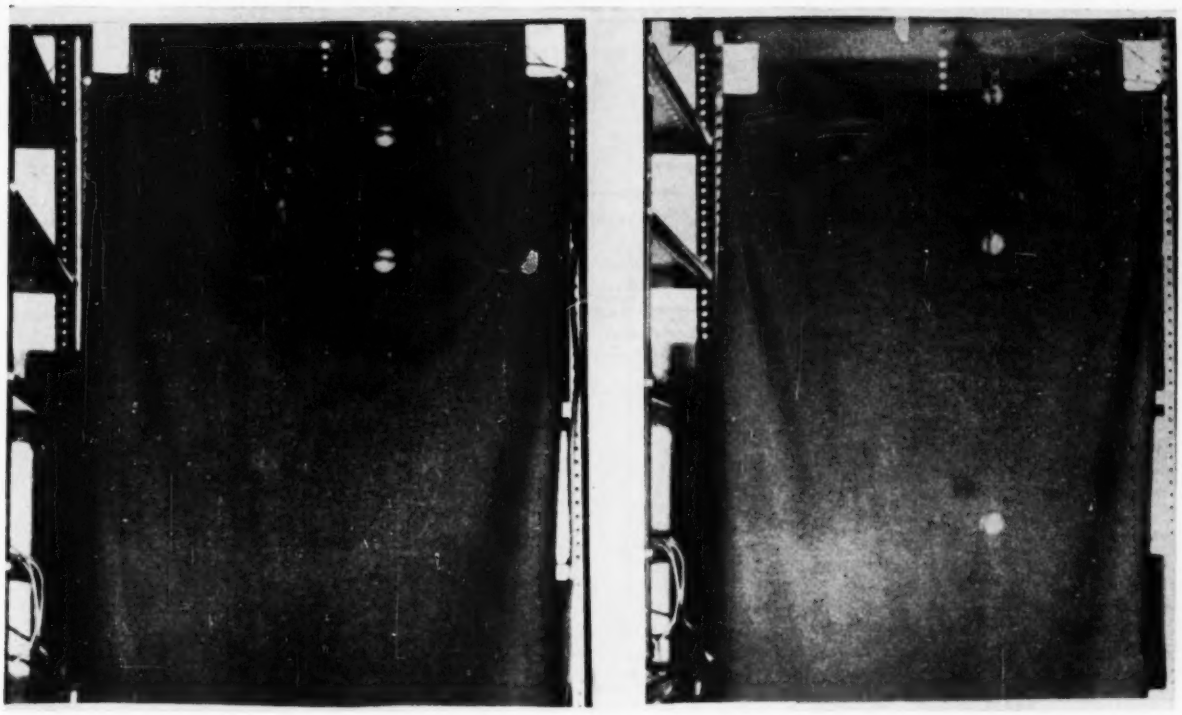

Fig. 1. Gravity free fall: left, Guide No. 50; right, Guide No. 42.

FT-220 at 40-j loading, the proper guide number is 70. Using Polaroid-Land film, test results are immediately available and the photographic quality has been found satisfactory for the purpose. Typical shots are shown in Fig. 1.

Circuit Description

A. Delayed-Trigger Generator (*Figs. 2 and 3*). The delayed-trigger generator consists of a trigger amplifier, a phantastron time base, and two amplitude comparison channels with separate output thyratrons. The time-base range is fixed by the capacitor value in the phantastron circuit, C103, C104 or C105. A vernier adjustment of run-down time is provided by R110.

The amplitude comparison diodes, V103B and V203A, are coupled to the phantastron plate. Each diode obtains a reference voltage from its own 10-turn helipot. The upper extreme of this reference voltage is adjustable by R112, which therefore provides a zero set for the time base. Signals from the comparison diodes are amplified and fed as triggers to the output thyratron grids.

B. Photoflash Unit (*Figs. 2 and 4*). The FT-220 photoflash lamp is triggered by the sudden application of 10 kv between its anode and cathode. The so-called trigger electrode of the photoflash tube may be connected to either anode or cathode, or left unconnected. An air gap holds off 10 kv to which the energy storage capacitor is charged. An auto-transformer in the thyratron plate circuit steps up the triggering pulse to several kilovolts, and this is applied to the third electrode in the spark gap. Ionization of the air in the gap then occurs and the energy storage capacitor for that particular spark gap discharges through the photoflash lamp.

Several seconds are required for the recharging of the capacitors after a flash. A neon lamp lights when the capacitors are fully charged.

Performance

The use of a phantastron time base affords a very linear calibration of time delay. Figure 5 shows typical calibration curves. No appreciable time jitter is present and the stability is good.

The joule loading in the present equipment is 12.5 j, 0.25 μf at 10 kv, giving a light flash of 5 megalumens peak and 15 μsec duration. The normal operating voltage of the FT-220 is 2 kv, but by the use of spark-gap switches an overvoltage operation is made possible.

As previously mentioned, effective stoppage of action is achieved since the flash duration is very short compared to the time interval between flashes. Using a focal length of 135 mm, a subject-to-camera distance of 12 ft, and assuming a resolution of 1 mil, it is possible to stop actions up to 150 ft/sec. Dark backgrounds (low reflectance) and light subjects give best results provided the proper guide number is used with the smallest possible lens aperture.

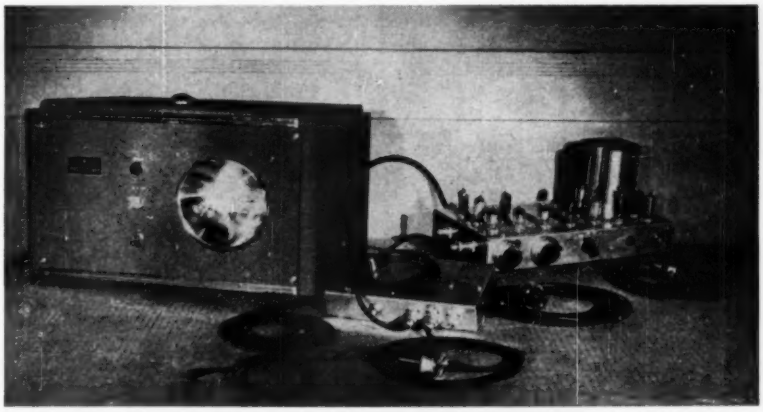

Fig. 2. Duo-flash equipment setup.

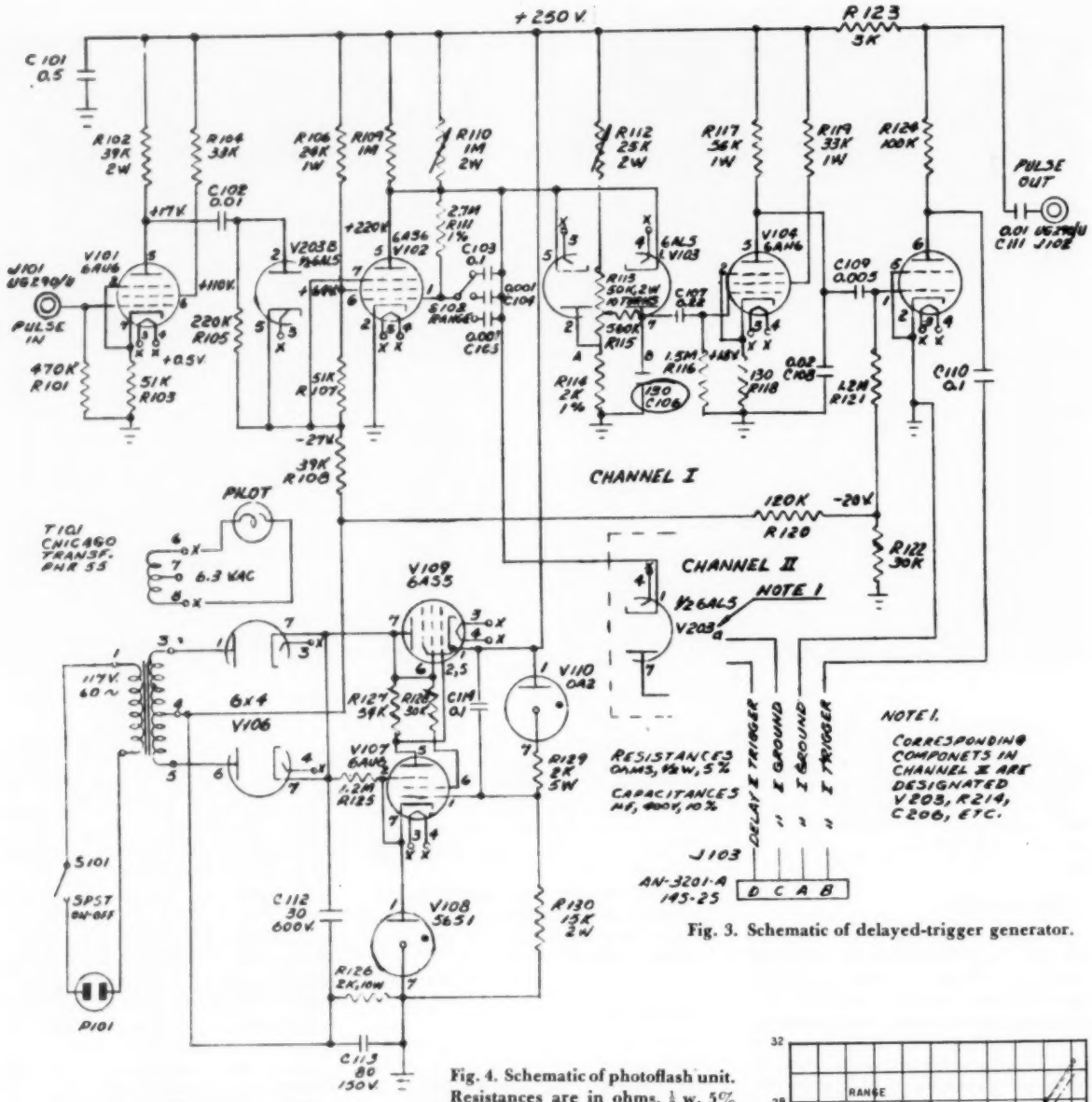

Fig. 3. Schematic of delayed-trigger generator.

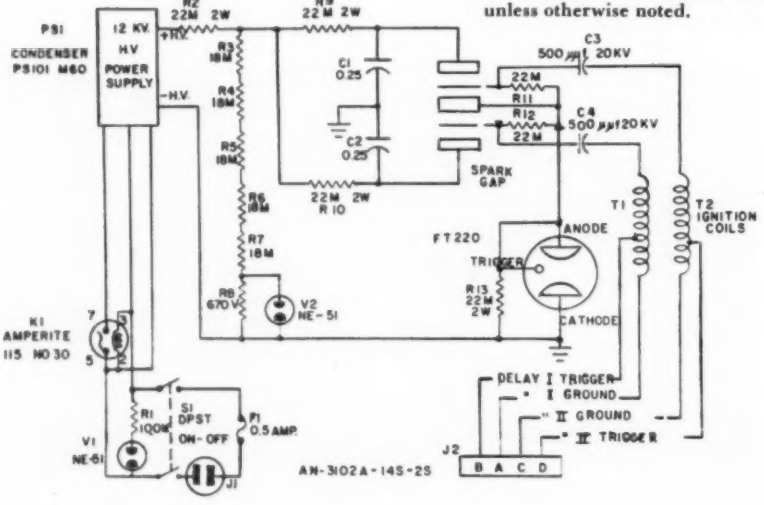

Fig. 4. Schematic of photoflash unit. Resistances are in ohms, ½ w, 5% unless otherwise noted.

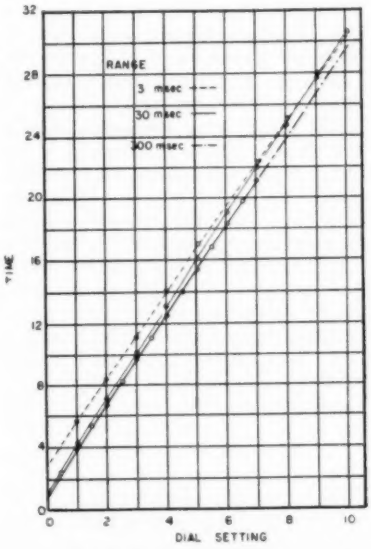

Fig. 5. Calibration curves.

Sensitometry of the Color Internegative Process

By C. R. ANDERSON, C. E. OSBORNE, F. A. RICHEY and W. L. SWIFT

The problems involved in obtaining optimum tone and color reproduction in 35mm motion-picture color prints are discussed. A color negative material is used for exposure in the camera and three separation positives are printed from it; then a duplicate color negative is made on an internegative material from the separation positives. The influence of the sensitometric characteristics of the individual films of this system requires the careful use of sensitometric analyses at each stage to determine the optimum printing and processing conditions. A procedure is described which has been found helpful in determining these conditions.

A GENERAL description of the sequence of operations required to make color prints from an original negative through separation positives, or internegative, and to color print film has been presented in earlier papers.[1,2] The purpose of this paper is to describe in more detail procedures which are useful in predicting the final results of this process.

Before entering the discussion of this problem, a brief review of these materials and operations may be in order. The materials used for this work were: Eastman Color Negative Safety Film, Type 5248; Eastman Panchromatic Separation Safety Film, Type 5216; Eastman Color Internegative Safety Film, Type 5245; and Eastman Color Print Safety Film, Type 5382; but many of these problems would be common to other types of films.

As shown in Fig. 1, pictures on Eastman Color Negative Film may be printed to Eastman Color Print Film to yield direct prints, or three individual exposures may be made on a registering printer through sharp-cutting filters to yield red, green and blue separation positives. These, in turn, are printed on the internegative film with green, blue and red filters, respectively. With correct exposure and processing, it is possible to obtain internegatives from most original negatives which match very well in density level and contrast, and which will produce prints of color quality comparable to direct prints from the same negatives.

Once the optimum conditions for exposing and processing the separation positives and the internegatives have been established for one normal original negative, it should be possible to use very nearly the same conditions of exposing and processing to get equally satisfactory results from other negatives of the same type.

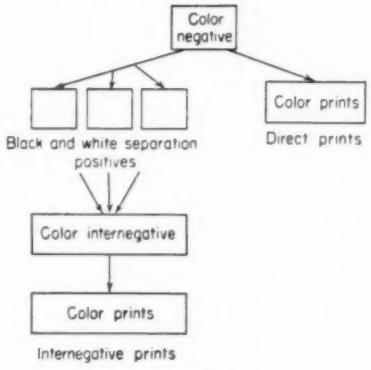

Fig. 1. Two methods for color print production.

The purpose of this paper is to describe a system which has been found more useful in determining these conditions and which requires less expenditure of time and effort than a trial-and-error method.

From a sensitometric standpoint, the objective is to make an internegative which will print as nearly as possible like the original negative with respect to the red, green and blue gammas obtained, and to make the internegative density level approach that of the original negative so closely that they may be intercut and printed with a minimum change in printer intensity and color balance at the splice.

The first step is the preparation of the sensitometric curves of the original negative film and a determination of the portions of these red, green and blue density curves, respectively, which correspond to the density range of a given negative scene. This is done by selecting a scene of extreme brightness range for this original calibration. It is helpful to include in the scene to be photographed a white card and dead black. A good black can be obtained by using a box lined with black velvet. The scene should then be photographed using normal illumination and exposure. At the time these picture negatives are processed, a balanced, neutral-scale, sensitometric exposure on the negative film should also be processed. The sensitometric curves are read on a color densitometer with red, green and blue filters,[2] and the curves are drawn, as shown in Fig. 2. From the processed picture negative, the areas of the whitest white and the blackest black are also read on the color densitometer, and these red, green and blue density values are plotted on the curves, as shown in the illustration. The portions between the points represent the regions of the curves which contain all pertinent picture information. Straight lines should be drawn on each curve connecting the highest and lowest picture density for ease in measuring the gamma.

Simple equations which express the objectives may be written:

$$\text{Density Range of Internegative} = \text{Density Range of Original Negative} \quad (1)$$

and

$$\text{Print-Through Gamma Internegative} = \text{Gamma Original Negative} \quad (2)$$

A sensitometric, neutral-scale exposure on the internegative film is now made and processed in the manner recommended. The red, green and blue densities are determined and plotted, as in the previous illustration for the original negative. The density readings for the white and black points from the original picture negative are also plotted on this internegative neutral curve, as shown in Fig. 3. At this point, the portions of the internegative curves must be deter-

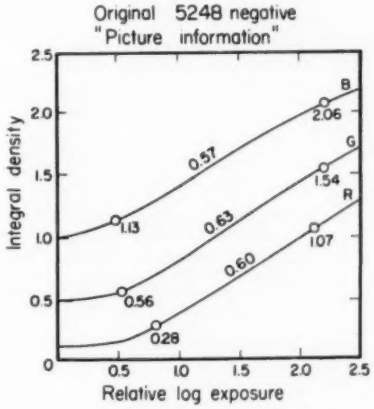

Fig. 2. Typical sensitometric curves of Eastman Color Negative Film. Density ranges of a test picture are indicated.

Communication No. 1671 from the Kodak Research Laboratories, by C. R. Anderson, C. E. Osborne, F. A. Richey and W. L. Swift, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y. Presented on October 8, 1953, at the Society's Convention at New York by F. A. Richey.
(This paper was received on July 12, 1954.)

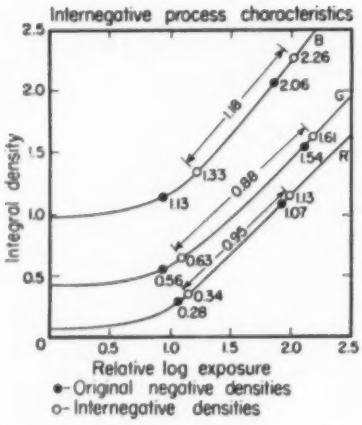

Fig. 3. Typical sensitometric curves of Eastman Color Internegative Film: ● — original negative picture density range; ○ — desired internegative picture density range.

mined which will be used to satisfy Eq. (1), and also employ the straight-line portions of these internegative curves. From the illustration it is apparent that the internegatives should not be made at exactly the same density level as the original picture negative, since this would result in a loss in shadow detail in the final print. It *is* preferable to use the higher densities, indicated by the circles, in order to operate on the straight-line portions of the internegative curves. There is another important reason for placing these points on the internegative curves. By connecting these points with straight lines the average gammas of the internegative can be defined over those portions of the curves which will be required to reproduce the original picture negative. This may seem like an elementary point, but very large errors may result from differences in opinion as to the correct way to define the gammas of the individual stages of the system.

Equation (2) can now be amplified by stating that the final gamma of the internegative reproduction of a sensitometric neutral scale is the product of the gammas of the individual films used. This value will be referred to as the print-through gamma of the internegative.

$$\gamma_N \times \gamma_S \times \gamma_{IN} = \text{Print-through } \gamma_{IN} = \gamma_N, \quad (2')$$

where

γ_N = measured process gamma of the negative film;
γ_S = measured process gamma of the separation positive film; and
γ_{IN} = measured process gamma of the internegative film.

Color photography is subject to certain complications which tend to frustrate simple mathematical statements. One of these complications occurs at this point. A "neutral" for the original negative might be defined as the red, green and blue densities resulting from the exposure of the negative to a gray object. Because of the presence of colored couplers which serve as masks, the negative film does not produce a visually neutral gray, but gives unequal red, green and blue densities to the eyes, and, as shown in Fig. 2, to the color densitometer. This results in a vertical displacement on the density scale. This so-called neutral can be shown as a spectrophotometric curve of one density level, as in Fig. 4, in which the densities at each wavelength are shown throughout the visible spectrum. The change between the wavelengths indicated (560 and 580 mμ) results in a 20% difference in density. In a sensitometric chart, a series of such patches read at these two wavelengths would result in gamma differences of 20% as well. This effect also occurs with densitometer or printer filters of different peak-wavelength transmissions or of different band widths. Similarly, the use of two photographic materials having their peak sensitivities at different wavelengths can result in a given dye neutral printing as though it had one density to one film and a different density to the other.

The calibration of a color densitometer is a specific operation. A color densitometer may be calibrated to measure the densities of a film in the same manner as seen by the human eye by the proper adjustment of (E_λ), the spectral energy distribution of the light source; (F_λ), the transmission characteristics of the filters used in the light path of the instrument; and (S_λ), the choice of a phototube having a surface of the proper spectral sensitivity.

This relationship is shown in Eq. (3).

$$\text{Densitometer Response} = \int E_\lambda F_\lambda S_\lambda d\lambda \quad (3)$$

For these density measurements of the negative and internegative films, the appearance of the films to the eye is not as important as their effect on the films to which they are printed in the motion-picture printers. It is, therefore, the *printing* densities and the *printing* gammas of the negative with respect to the two different films to which it may be printed, the panchromatic separation positive and the color-print film, which are of interest.

As in the case of the densitometer response, the film response in the printer is a function of (E_λ'), the energy distribution of the light source of the printer; (F_λ'), the transmission of the filters used in the printer; and (S_λ'), the relative sensitivity at each wavelength of the film being exposed. This relationship is shown in Eq. (4):

$$\text{Film Response} = E_\lambda' F_\lambda' S_\lambda' d\lambda \quad (4)$$

It is possible with photoelectric densitometers to select filters such that the overall response will almost match any one of these visual or printing densities,

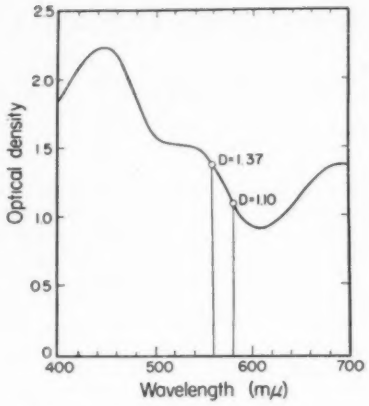

Fig. 4. Spectrophotometric curve of Eastman Color Negative (Type 5248). Reproduction of gray subject.

but not any two of these printing densities simultaneously.

It now becomes necessary to modify Eq. (2′) so that it will predict how these films will print rather than how the densitometer indicates they should print. When narrow-band filters are used in the densitometers and printers:

$$\gamma_p = \gamma_D \left(\frac{\gamma_p}{\gamma_D}\right) \quad (5)$$

or

$$\gamma_p = \gamma_D K$$

where

γ_p = printing gamma; and
γ_D = measured integral density gamma

Thus the measured gammas made with the densitometer may be converted to printing gammas by multiplying the measured gammas by a factor, K, which is the ratio of the printing gamma to the measured gamma. It should be pointed out that at each printing stage there are *three* of these constants, one each for the reproduction of the red, the green and the blue records, respectively.

The accuracy of Eq. (2′) may now be improved as follows:

$$\gamma_N K_1 \times \gamma_S K_2 \times \gamma_{IN} K_3 = \text{Print-Through } \gamma_{IN} K_3 = \gamma_N K_4, \quad (2'')$$

where γ_N, γ_S and γ_{IN} are measured process gammas of the original negative, the separation positive and the internegative, respectively;

and

$$K_1 = \frac{\gamma_p \text{ of negative to separation positive.}}{\gamma_N}$$

$$K_2 = \frac{\gamma_p \text{ of separation positive to internegative.}}{\gamma_S}$$

$$K_3 = \frac{\gamma_p \text{ of internegative to color-print film.}}{\gamma_{IN}}$$

$$K_4 = \frac{\gamma_p \text{ of negative to color-print film.}}{\gamma_N}$$

The ratio of printing gamma to densitometry gamma is almost equal for the negative and internegative to the print film. Thus, $K_3 = K_4$, and these may

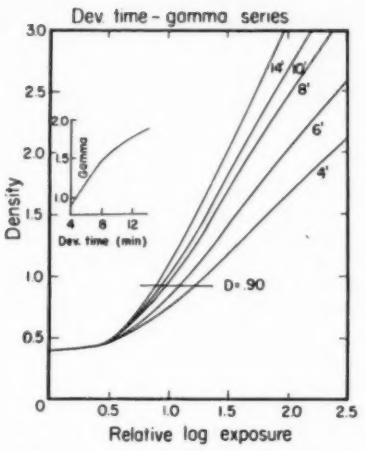

Fig. 5. Eastman Separation Positive Film development time-gamma series for Wratten No. 70 filter exposures.

be cancelled out of the equation. Also, since γ_N occurs on each side of the equation, these terms may be dropped. For the contact printing of the separation positives, the silver image does have sufficient color so that slightly different contrasts and values of K_2 are obtained by reading or printing with red, green and blue filters. For a given case, however, the product of K_1 and K_2 may be considered to be equal to a single constant K. The simplified expression becomes:

$$K \times \gamma_S \times \gamma_{IN} = 1$$

or

$$\gamma_S = \frac{1}{K\gamma_{IN}}.$$

Except for the presence of the constant K, this simple equation might have been a commonly accepted fact, namely, that the correct red, green and blue process gammas for the separation positive film are the reciprocals of the process gammas of the red, green and blue density curves of the internegative. However, the values of K, for the red, green and blue separation positives are essential to the successful determination of the required separation positive gammas. Unfortunately, the values of these constants may vary for different densitometers and printers. Although one typical set of values may be given by way of illustration, the method employed for the determination of these constants is of greater importance.

As in many photographic problems, it is wiser in this case to let the equipment and films solve the problem than to attempt the integrations. Assuming that the values of K_1 for the red, green and blue records are equal to unity, a trial set of separation positives is made from a processed-negative, sensitometric, gray-scale exposure and a typical picture. For the purposes of this test, the process gammas of the positives the reciprocals of the process gammas of the internegative.

Development-time series are run on separate red, green and blue sensitometric exposures of the separation positive film, using the same red-, green- and blue-filter combinations which are normally used to make the separations from the picture negative. These are read on the densitometer, care being taken to use a specific densitometer-filter condition for this purpose, and are plotted in the conventional way. These provide the working tools for a given emulsion number of film, developing machine and black-and-white negative developer formula. A typical time-gamma calibration for red separation positives is shown in Fig. 5.

This calibration serves an additional purpose in showing us the lowest density on the positive film to which the picture highlight can be printed and which will still allow the rest of the picture to be placed on the straight-line portion of the curve. This is a density of about 0.90 for the example shown.

These positives are printed onto the internegative film, and the print-through gammas of the resulting neutral scale on the internegative are measured. Returning to Eq. (2), the actual values are substituted in it. In the case of the reproduction of the red record, these values are:

$$\gamma_N K \times \gamma_S \times \gamma_{IN} = \text{Print-Through } \gamma_{IN}$$

$$0.60K \times 0.88 \times 0.95 = 0.61$$

or

$$K = \frac{0.61}{0.60 \times 0.88 \times 0.95 = 1.21}$$

Under extremely fortunate and rare circumstances, K might turn out to be equal to 1.00, as has been assumed for the purpose of this trial, but, in these typical calculations, the values obtained for Red K, Green K and Blue K were 1.21, 1.13 and 0.92, respectively.

Again it should be emphasized that these values will very likely be different for different types of densitometers and for printers employing different light sources and/or filters. This determination of the constants or the equivalent of it should be performed at least once for a given set of equipment, and again each time a radical change in equipment is made.

Finally, the essential working equations obtained are:

$$\gamma_S \text{ for the Red Separation Positive} = \frac{1}{1.21 \times \text{Red Process } \gamma_{\text{Internegative}}}$$

$$\gamma_S \text{ for Green Separation Positive} = \frac{1}{1.13 \times \text{Green Process } \gamma_{\text{Internegative}}}$$

$$\gamma_S \text{ for the Blue Separation Positive} = \frac{1}{0.92 \times \text{Blue Process } \gamma_{\text{Internegative}}}$$

There are many cases where either optical or contact printers may be used in making separation positives and internegatives. Since the effective printing density of a film for optical and contact printing conditions is somewhat analogous to the specular and diffuse densities, respectively, of the film, some difficulty may be anticipated with the validity of the equation for determining the required separation positive gammas. This is especially true in the case where the separation positives are optically printed on the internegative film. The silver image does have higher densities and gammas in optical printing than in contact printing by a factor of the order of 25%.

This factor, however, is included in the individual values for the constant K for the specific printing equipment for each stage. It should be remembered, however, that different values of the constants and therefore different process gammas in the separation-positive stage may be required for optimum results wherever a change in printing conditions is made.

It was stated earlier that the ratios of printing gamma to measured gamma for the negative and internegative films to the color-print film were equal. Under extreme conditions, this may not be true. In such a case, the values of K_3 and K_4 would not be dropped, but the solution would then involve printing the internegative print-through tests and the original negative on print film and determining these values independently.

There are several additional points which should be emphasized in order to be certain that the system will perform according to this prediction.

The test exposures as well as the final prints must be made with the densities of the test picture correctly placed on straight-line portions of the separation positive and the internegative films. Where any deviation from a straight line occurs, the straight line connecting the points of extreme brightness range on the picture should be used for measuring the "average" gamma.

Most photographic materials exhibit slightly different sensitometric characteristics for long-time, low-intensity exposures than for short-time, high-intensity exposures. Manufacturers control the behavior of their photographic products for the levels of time and intensities under which the products are to be used. Different emulsion numbers of a given product may show slightly different degrees of reciprocity-law failure. A misleading prediction of film characteristics on high-intensity printers may result from the use of very-low-intensity sensitometers. For this reason, it is desirable to use sensitometers having intensity levels and shutter times comparable to those of the motion-picture printers being used.

Although the storage of separation positive film at 78 F, or average room temperature, for two days causes no difficulty, a storage period of seven days

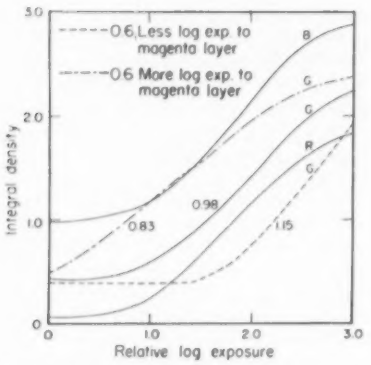

Fig. 6. Balanced and unbalanced magenta layer exposures of internegative film.

will result in a speed loss of 0.15 log E. For this reason, the sensitometric scales as well as the picture tests should be exposed and processed within a two-day period. Alternatively, these exposed films should be stored at 40 F or lower.

In measuring the process gammas of the internegative film, it is necessary to make the sensitometric exposures with the red-, green- and blue-light intensities adjusted to place the curves in very nearly the same *orientation* of densities red/green/blue as those which are to be used in the internegative picture. In Fig. 6 a correctly exposed internegative is shown with the desired alignment of the red, green and blue shadow densities. Also shown in dotted lines are variations in exposure of the magenta layer on each side of the normal. In Fig. 7 the effect of this incorrect exposure on the measured gammas of the film is shown.

Similarly, variations in the exposure of the cyan layer also have an effect on the green-gamma measurement of the internegative film. Allowing a tolerance of ± 5% from normal, these data show that the sensitometric exposures must be correct to within ± 0.20 log E for the magenta layer (blue exposure) and to within ± 0.30 log E for the cyan layer (green exposure). This is not an unusually strict requirement but is, of course, of greater importance to the accurate determination of the constants than for routine process control purposes.

Similar tests have shown that variations in exposure of the yellow dye layer are less important, provided the cyan magenta dye layer exposures are correctly placed with respect to each other.

When the correct gammas for the separation positives have been determined, a printer calibration system may be worked out for specific equipment which is helpful in obtaining correctly exposed separation positives and internegatives without using preliminary printer-exposure tests with each different original negative.

A camera exposure series is prepared on the negative film and processed to provide test films having a wide range of density levels. These are then printed with variations in printer aperture for each of a number of lamps and neutral density values in the printer beam for making red, green and blue separation positives. The data resulting from these exposure tests are then plotted as a family of lines, each representing a given lamp and neutral density value in the printer. In the case of the red separation exposure, Fig. 8, the correct printer aperture (required to print the highlight density in the shoulder of the negative at the beginning of the straight-line portion of the separation positive) is plotted against the red density of the highlight region in the original negative. Similar curves may be obtained for predicting the correct blue and green separation exposures.

In a similar manner, the printer may be calibrated to indicate the printer settings required to give a correctly exposed internegative from density readings of this same highlight area on the separation positives.

In this case again, the data shown here will not be of specific value for different printers and densitometers.

This discussion would not be complete without a statement about the tolerances within which one must work in such a

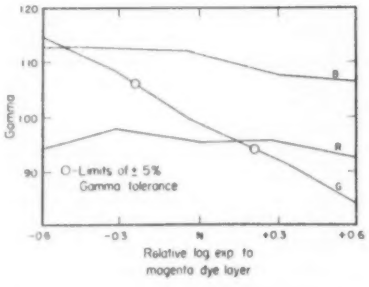

Fig. 7. Effect of unbalanced exposure on measured gammas of internegative film.

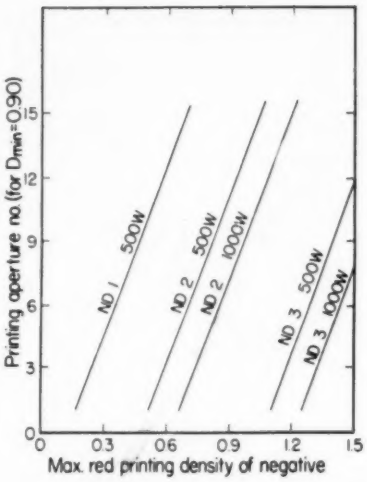

Fig. 8. Red separation positive exposure determination chart; Wratten No. 70 filter exposure; separation positive printer curves for 10-min development.

system. Although exact tolerances have not been determined, it appears likely from practical observations that a maximum total spread in gammas of the order of 10% is tolerable.

None of the foregoing methods will be found of great value unless there is good reproducibility with respect to processing conditions and with respect to the sensitometer, densitometer and printer. It will be found that these are problems that must be solved in any event and that the procedures used must be employed in one form or another. When the initial calibrations have been completed, most of the work has been done. New problems concerning the system can be recognized, analyzed and corrected more quickly than by repeating an empirical determination of the conditions for each new set of processed negatives.

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A Rapid-Scanning Microdensitometer

By W. R. J. BROWN

A simple microdensitometer is described. It is a scanning unit which may be used in conjunction with a normal microscope. An enlarged real image of a film sample is moved across a stationary slit. The image motion is provided by a rotating block of glass. An electrical signal (from a phototube behind the slit) is converted to a density signal and is presented on a cathode-ray oscilloscope Some uses of microdensitometric traces are suggested.

One of the essential qualities of a photographic system is that it be capable of rendering a subject in such a way that the reproduction appears sharp or well defined, and that it shows all important detail. Occasionally, it is desirable or even essential to add diffusion. Nevertheless, any process or apparatus which necessarily makes an unsharp picture is unsatisfactory.

The problem of maintaining image sharpness through a complicated series of motion-picture printers and processing stages becomes a very serious one indeed. This is particularly true when special effects are required. The number of stages involved, together with the difficulty of assessing the sharpness of color negatives and internegatives, often makes it difficult to establish the point at which the unsharpness was introduced.

A traditional method of indicating the ability of a film to record detail has been the measurement of *resolving power*. This type of measurement has been used extensively in the past and not without some success for the purpose intended. However, a number of workers have noted that such a measurement does not necessarily correlate with a subjective evaluation of picture sharpness. Some outstanding discrepancies between resolving-power measurements and picture sharpness have been pointed out by Wolfe and Eisen[1] and by Higgins and Jones.[2] After investigating a number of criteria of photographic sharpness, Higgins and Jones proposed a method with which sharpness could be measured, and the results of such measurements have been expressed in terms of a new quantity designated as "acutance." Acutance is computed from the microdistribution of density at the edge of a line image on the photographic material. It is fairly evident that any successful analysis of image sharpness must be based on this density distribution.

What is much less evident, however, is a simple method of obtaining the microdensitometric curve. The microdensitometer required to study photographic sharpness adequately should be capable of reading density in as narrow an area as one micron on the film. This usually exceeds the capabilities of commercial instruments, which have been designed primarily to measure densities on spectroscopic plates.[3] More complex instruments have been built that have adequate resolution but they are usually expensive and complicated. None of them provides a readily available device for the study of photographic sharpness.

These instruments fall into roughly three classes: those in which the sample is moved,[4] those in which an image of the light source is moved,[5] and those in which an image of the sample is moved. This instrument falls into the last category. The instrument consists of a simple scanning unit which may be placed above an ordinary microscope (such as a microscope used to study resolving power). The microscope and its objectives should be of good quality since it is usually desirable to scan color-film samples with red, green or blue light. Achromatic microscope objectives are satisfactory rather than apochromatic objectives. In most cases, the residual aberrations in nearly monochromatic light are less with an achromat than with an apochromat. Hence, a good achromat should give equal or better results than the more expensive apochromat. The general appearance of the unit is shown in Fig. 1. The microscope and its illuminator are shown in their conventional arrangement, the illuminator on the left, and the microscope in the center. Above the microscope is the scanning unit, supported for convenience on an enlarger stand. This facilitiates moving the unit out of the way if the microscope is to be used for direct viewing, for photomicrographs, etc.

The microscope is adjusted so that the enlarged image of the film sample on the microscope's stage is projected onto a fine slit. Behind this slit is placed a photomultiplier-type phototube. The phototube will record the amount of light from the sample passing through the slit. If the image is made to move past the slit, then the photocell will record the difference of light passing through each point on the sample. If the output of the photocell is amplified by a logarithmic amplifier, then the electrical output will be equivalent to the density of the sample. This electrical signal may be viewed on a cathode-ray oscilloscope.

A simple method of moving the enlarged image past the slit is to insert a plane-parallel plate of glass into the optical path. If this plate is rotated, the image is shifted laterally across the slit. This same method of image shifting is used to compensate for film movement in high-speed cameras. The actual path of a ray through the glass block is shown in Fig. 2.

This figure shows that the image is not displaced when the plate is at right angles to the optical axis. As the plate rotates uniformly in one direction, the image will be displaced laterally across the slit in one direction (in the same way that film motion is compensated in a high-speed camera). The image will move across the slit twice for each complete rotation of the glass plate. Each time the image does cross the slit, the photocell will record the light transmitted by each point of the sample.

If the plate is attached to the shaft of a small motor and rotated, the photocell

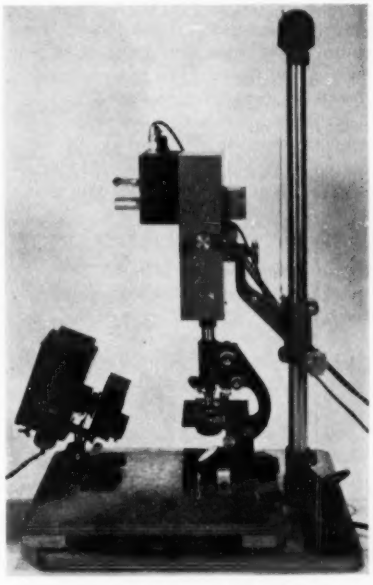

Fig. 1. General view of the microscope, illuminator, and scanner mounted on an enlarger stand.

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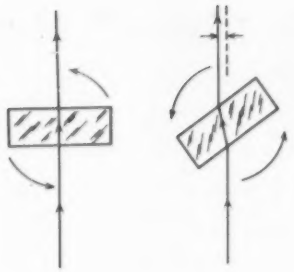

Fig. 2. Displacement of the optical axis when passing through a plane-parallel plate of glass.

will generate an a-c signal whose frequency is twice the rotational frequency of the motor or plate. Each full cycle of this wave will be equivalent to a scan of transmission vs. distance across the film sample. The signal may be amplified in a logarithmic amplifier and presented on a cathode-ray oscilloscope. Since the image moves fairly uniformly across the slit, the trace on the oscilloscope is a curve of density vs. distance on the sample. This trace is the desired microdensitometer curve.

The motion of the image is not exactly uniform as the glass block rotates. The actual displacement of the image as the block rotates is shown in Fig. 3. This curve is computed for the typical glass block of 6-mm thickness and having an index of refraction of 1.60. The motion of the image is exactly uniform when the plate is at right angles to the incident beam (0° rotation of the plate). As the plate rotates more and more, the displacement of the image gradually departs from the ideal curve which represents uniform motion. This departure from uniform motion of the image across the slit results in a distortion of the distance scale when the density vs. distance curve is viewed on the face of the oscilloscope. The nature of this distortion is a compression of the distance scale at both ends of the trace. The percent error is shown by the arrows in Fig. 3.

In practice, this is not serious. The edge exposure which is to be traced is normally adjusted on the microscope stage until it is centered in the microscope field. When this is done, the distortion occurs at the ends of the trace where it is usually not important. An error of 10% at the ends of the trace cannot usually be detected.

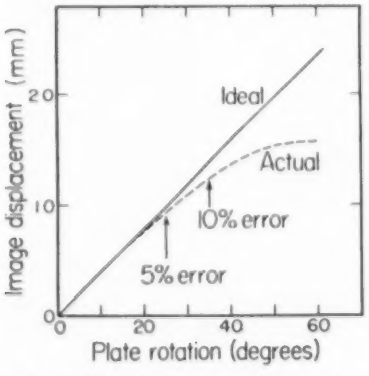

Fig. 3. The displacement of the optical axis as a function of plate rotation.

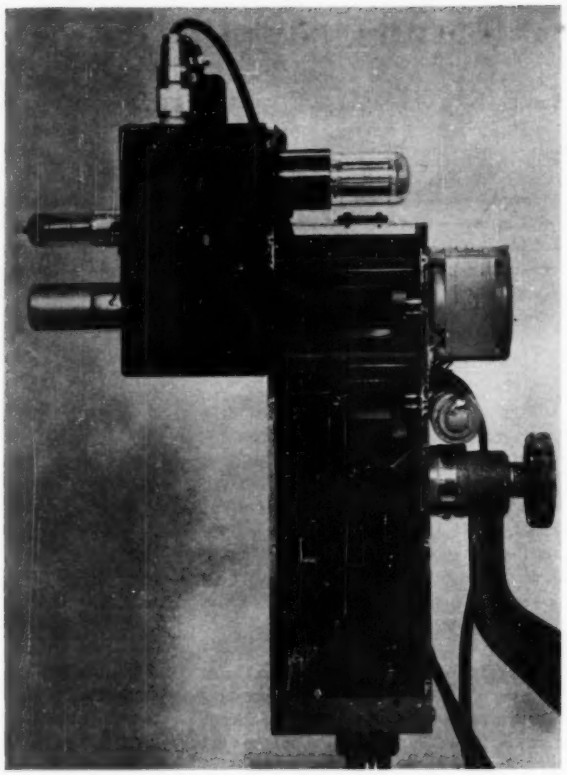

Fig. 4. Side view of scanner with side covers removed.

In Fig. 4 the scanner is shown with the side covers removed. The microscope eyepiece fits into a velvet-lined collar to reduce stray light. This prevents room illumination from reducing the image contrast and apparent density range. Near the top is the small motor with the rotating glass plate attached to its shaft. Above this is the slit and the photocell. No optics beyond the glass plate are necessary because the photocell collects all of the light passed through the slit. The base of the photomultiplier extends directly into the amplifier chassis attached to the base of the instrument. Leads from the amplifier go to the power supply and the oscilloscope.

Below the rotating plate is fixed a half-silvered mirror to permit the operator to view by reflection the image formed by the microscope on the white focusing screen around the slit. Image-forming light passes through this mirror to reach the slit. A reflection of the rotating plate can be seen in the mirror. This half-silvered mirror does reduce the maximum density through which the microdensitometer will record. If it is desired to increase the sensitivity, this mirror could be hinged to swing out of the way when a measurement is being made.

The slit is made photographically on Kodak High Resolution Plates and is $\frac{7}{8}$ in. long and 0.1 mm wide. The technique of producing such a slit is quite simple. A clear, white line is photographed in a camera with the correct reduction so that a fine, dark line is produced on the plate. If this exposure is printed with good contact and with specular light onto a similar plate, a fine, clear line is produced. Since the material has extremely high contrast, the resulting clear line is very sharp, almost irrespective of the camera lens used to make the printing master. The maximum density is also very high. Slits in any desirable slit width can be made very easily in this fashion.

A slit prepared in this way is mounted on a metal plate in which a rectangular slot has been cut. This plate serves as a partition separating the photocell from the scanner. For convenience, the slit is adjusted so that it is parallel to the edges of the rectangular slot. The side of the metal partition facing the microscope is painted white. This white area provides a focusing screen upon which the image is projected. It is coplanar with the slit and so serves as a focal plane for the image scanned by the slit.

The photomultiplier tube used is a Type 931A. Higher-sensitivity cells are ordinarily not needed unless the film sample is unusually dense or the magnification of the microscope is very high. The circuit for the photomultiplier tube, amplifier and logarithmic amplifier are shown in Fig. 5. The signal for the

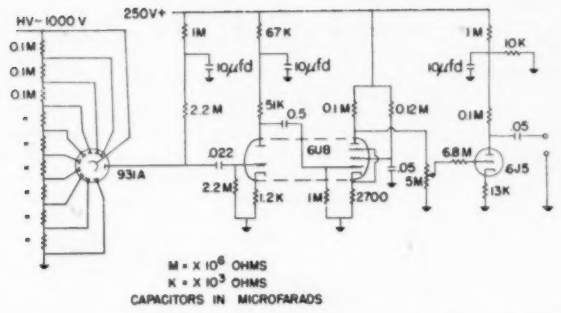

Fig. 5. Circuit diagram for photocell, preamplifier and logarithmic amplifier. The output terminals are connected to an oscilloscope.

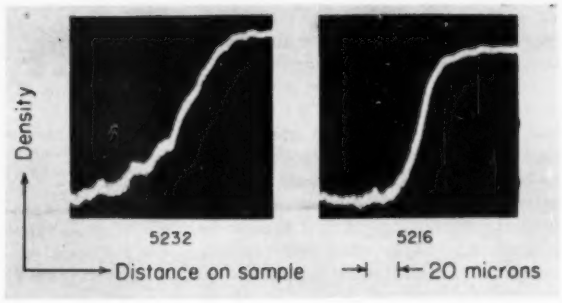

Fig. 6. Typical microdensitometer traces for two film samples.

oscilloscope is proportional to the density of the sample: the conversion of the signal proportional to the transmission of the sample which the photocell provides to a signal proportional to density is made by the Type 6J5 tube. This circuit is linear in density over a range of about two. The density range can be extended, if necessary, by increasing the plate voltage on the pentode half of the Type 6U8 tube.

Any convenient power supply can be used to supply the plate voltage and high voltage to the amplifier. It is convenient to have the high-voltage supply adjustable through a range of 650 to 1200 volts. This adjustment is used to set the optimum conditions for gain and signal-to-noise ratio from the photomultiplier. The setting of this control is likely to differ somewhat for different phototubes and scanning units.

Normally, microdensitometer traces are made across one edge of a knife-edge exposure on the film sample. In order to obtain the true sharpness of the edge, the image of the film sample must be focused and aligned parallel to the edges of the slit. The operator can easily make this adjustment while viewing the projected image on the white screen, when the motor is stopped and the glass plate is not rotating. This image can be seen by reflection in the half-silvered mirror. When the operator is satisfied with the alignment, he sets the plate in rotation and the trace appears on the oscilloscope.

The actual scale of the trace on the cathode-ray face depends on the adjustments of the oscilloscope controls. Since most microdensitometer measurements are comparative, this is of no particular disadvantage. The oscilloscope controls are adjusted and traces are obtained for each of the samples in turn. These traces may then be compared for sharpness.

The trace on the face of the oscilloscope can be recorded in a great many ways. The simplest way is to trace it with a pencil onto a piece of tracing paper. More elegant photographic methods are available which enable an exact record to be made with very convenient equipment. The best recording technique depends on the amount of use the equipment receives and the cost of the equipment.

Traces for two film materials are shown in Fig. 6. The films used in this example are Eastman Super-XX Panchromatic Negative Safety Film, Type 5232, on the left, and Eastman Panchromatic Separation Safety Film, Type 5216, on the right.

It can be seen that the density distribution is closer to the edge of the line for Type 5216 than for Type 5232. The actual calculation of acutance for these two edges could be made as suggested by Higgins and Jones. However, for a case as striking as this one, even the most naive observer would have no difficulty in deciding which material was capable of sharper pictures.

This sharpness difference might have been expected. Panchromatic Separation Safety Film, being an intermediate stage in production, has been made as sharp as possible to avoid any degradation of the final print. A camera negative material must be sufficiently sensitive to receive adequate exposure under a variety of lighting conditions. This usually results in a somewhat less sharp image than could be obtained if slower emulsions had been used.

If an absolute calibration of density vs. distance is required, a film sample which has been calibrated in a conventional microdensitometer may be used. The curve on the oscilloscope can then be adjusted to fit the standard curve. All succeeding curves will have the same coordinates as the original trace.

Another method of establishing the distance scale of the trace is to scan a variable-density soundtrack recorded with a high-frequency note. The geometric distance between peaks of the image is known from the geometry of the soundtrack. The distance scale on the oscilloscope trace can then be set by adjusting the horizontal gain on the oscilloscope until the convenient linear magnification is obtained. A further possibility is the use of a stage micrometer on the microscope stage. This provides precisely placed lines which can be traced to allow setting linear magnification of the trace. There are many other alternatives which may be found convenient under other conditions.

One of the great advantages of an image-scanning microdensitometer is that the scanning rate depends on the image magnification. For a 50° rotation and a 6-mm plate of glass of index 1.60, the image is shifted 1.84 mm. This is the distance that the final image is shifted, irrespective of the optics used to magnify the sample. If the magnification of the microscope is fifty times, which would be a representative value for scanning color-negative materials, then the area of the sample scanned would be 37 μ. If a film sample with very high sharpness, such as Panchromatic Separation Safety Film is to be examined, then a larger magnification, e.g., one hundred times, may be used. The trace would cover a correspondingly smaller part of the sample (e.g. 18 μ). This ability to change the scanning area as the magnification is changed is very desirable when the trace is presented on an oscilloscope.

A further advantage is the extremely high magnifications that can be used. Since the film sample is stationary, an oil-immersion objective may be used on the microscope. This yields a very high magnification image with high resolution. In this way, the scanner produces microdensitometer traces of very small areas. Admittedly, such samples are usually encountered only in research work; however, the availability of such a high resolution is desirable for the rare cases where it is needed.

It might not be amiss at this point to suggest some further uses for the microdensitometer traces. In general, studies of picture sharpness can be made better from microdensitometer traces than from any other method of measurement. There comes to mind, therefore, all of the problems of camera focus and alignment, motion-picture printer sharpness (due to quality of contact, diffusion,

etc.), sharpness of kinescope recordings, etc. By removing the microscope and scanner and mounting them on an optical bench, the image of a lens may be examined directly. To do this, it is only necessary to form an image of a knife-edge by the lens under test and to focus the microscope scanner on this aerial image. The scanner will then show the distribution of light around the lens image. The sharpness of the image of the edge may be studied at various apertures and with color filters. Since the signal to the oscilloscope may be observed before or after the logarithmic amplifier, either the distribution of illuminance of the image or the log illuminance may be presented.

The fact that the output is an a-c waveform suggests that a great many calculations could be made on the wave by electrical analog computers.

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Discussion

C. E. Beachell (National Film Board of Canada): Have you experimented with scanning density gradients with a very small spot such as might be produced by adding another scanning slit at ninety degrees to the fixed slit?

Mr. Brown: No, this has not been done. This type of measurement presents difficulties due to the small amount of light available to the photocell. A further difficulty is caused by the grain of the film. If the film sample is scanned with, say, a one-micron square aperture, then the aperture is smaller than the graininess pattern in the film. As a result, the microdensitometer trace shows a considerable degree of variability due to the individual grains in the film. This tends to obscure the density gradient which we are interested in measuring.

If a slit is used to scan the sample which is long compared to its width, the effect of graininess is greatly reduced. The photocell measures the average transmission of the film sample enclosed by the slit. Since the slit is long, several hundred grains will be included. The density read under these conditions is a good average value for that position on the film sample. In general, it may be said that microdensitometer curves traced with a long slit are smoother, more easily interpreted, and more reproducible than those traced with a small aperture.

Applications of Television to Military Operations

By H. C. OPPENHEIMER

The Signal Corps is charged with exploring the areas of application of television in military operations. As a part of this program, the Signal Corps has been conducting a series of studies in the fields of tactical and training uses of television.

Insofar as the military application of television is concerned the Army feels that there are three broad fields of use:

1. Television as a *training and educational medium* to incorporate or be incorporated into present methods of training, where applicable.

2. Television as a *tactical aid*, whereby the overall mission of a unit in combat can best be accomplished with a minimum expenditure of life, time and money.

3. Television as a *technical tool*, to be used primarily for viewing objects in inaccessible places or objects with which direct contact would be dangerous, such as contaminated or radioactive substances.

In order to define these areas of best military application, it was determined that the most practical and economical approach would be to use general nature type of equipment to explore these broad fields of use and then concentrate money and time on research and development projects in the areas showing the most promise.

To this end the Signal Corps put together the Signal Corps Mobile Television System, a mobile, selfcontained and selfpowered, television system consisting of three field cameras and a film pick up chain, mounted and transported in four tractor trailers (Fig. 1).

Initial operations with this equipment indicated that certain changes and modifications should be made immediately. Therefore, an Airborne TV System operating out of an L-20 DeHaviland plane was added and a fifth van containing air-ground receivers and film recording facilities was procured.

With these changes and additions, the Signal Corps Mobile Television System was launched on a series of exploratory exercises in February 1953.

Training by Television

During 1953, the Mobile Unit visited eleven different Military posts in these exploratory exercises. Initial surveys showed many possibilities for using television as a training medium with some of its desirable features being the ability to: conserve or gain maximum utilization of facilities, equipment, training aids and instructor personnel; present material where the immediacy requirements preclude utilization of any other method; give identical or best instruction to a large or geographically scattered group; reduced or increase the relative size of an object for practical purposes of presentation; or bring a distant or inaccessible object before a group.

Some preliminary evaluation had been done in the training field but more conclusive answers were needed before the Signal Corps could launch any extensive program of television training installations. Therefore, a comprehensive research evaluation study was established in October 1953 to obtain some of the answers desired. The operational aspects of this study were conducted by the Signal Corps Mobile Television System assisted by the Television Branch of the Southeastern Signal School, Camp Gordon, Ga. The research evaluation was done by the Human Resources Research Office, George Washington University. The study was divided into two phases.

The major aim of Phase I was to obtain an evaluation of the comparative training effectiveness of instruction presented via television and instruction presented through ordinary means, such as platform lecture and demonstration.

In setting up this phase, it was decided that the Army's eight weeks basic course would be the most desirable vehicle on which to base the study. This area represents one of the biggest Army investments in training time and effort.

Presented on May 7, 1954, at the Society's Convention at Washington, D.C., by Capt. H. C. Oppenheimer, Chief, TV Branch, Army Pictorial Service Div., Dept. of the Army, Washington 25, D.C.
(This paper was received on July 19, 1954.)

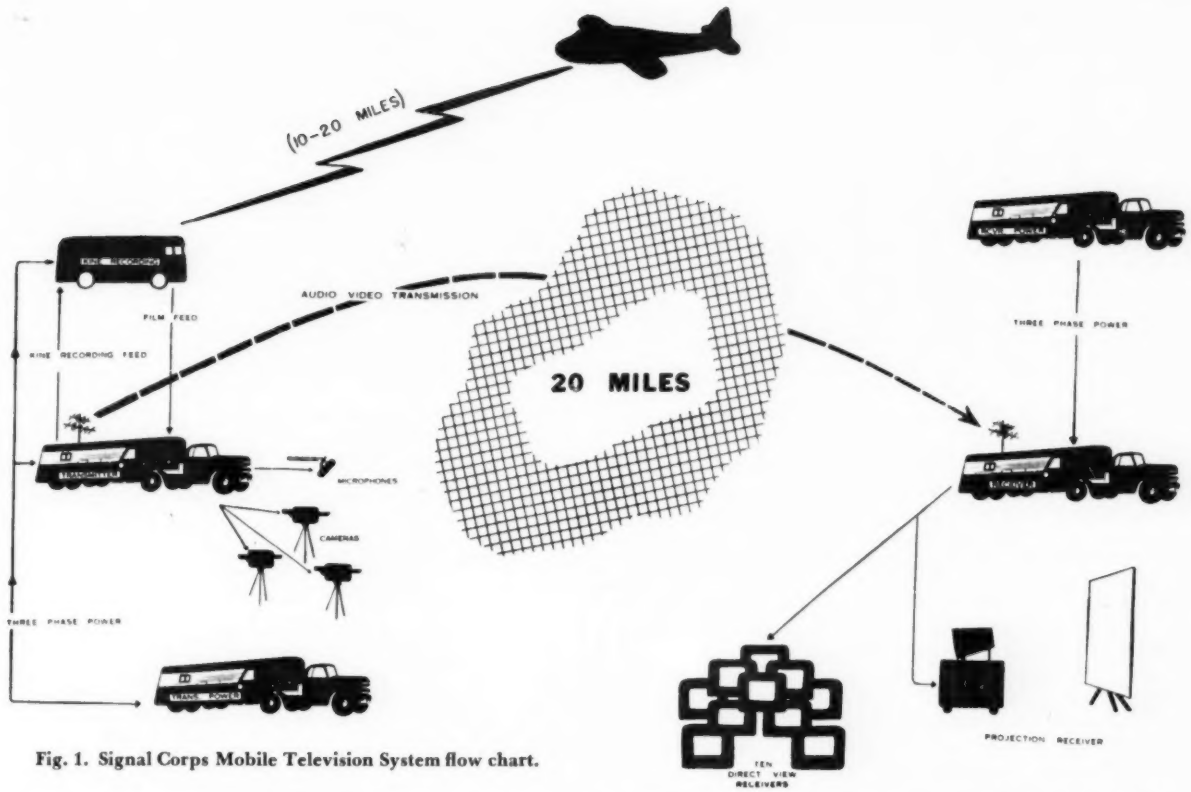

Fig. 1. Signal Corps Mobile Television System flow chart.

The large number of trainees undergoing this training would provide a suitable sample for study. The variety of skills and information taught during basic training would also provide an adequate sample of subject matters for making the basic evaluation, and, finally, the availability of trained instructors and training materials would lead to economies in training time and preparation.

The eight weeks course was reviewed and fourteen hours of representative instruction were chosen to be presented by television. The fourteen hours were so chosen as to be representative or typical of the skills and information taught in the first eight weeks of the basic training cycle. Throughout this and the subsequent Phase, considerable effort was made to insure that the results would be reliable and all possible steps were taken to eliminate any extraneous factors that might tend to invalidate the study. The trainees were matched throughout according to their I.Q. and for this first "comparative" phase, the television-presented instruction was made as similar as possible to the live. This Phase was not designed to change or reorganize regular Army instruction for television purposes or to systematically pursue factors leading to the most effective television presentation. Straightforward instruction was given with no effort made to insert any production values or special "gimmicks" other than those inherent to the medium, such as close-ups, superimpositions, camera cuts, etc. The training aids used in the platform instruction were used for television. The lessons were kept the same length. Instructors who taught over television also taught live. This latter was done to avoid any possibility that the results might be affected by a difference of instructors. All in all, 43 companies were used in 103 different training and testing situations, or about 12,000 trainees were given about 45,000 tests. There were 56 hours of television, with parallel regular instruction, given over a period of two months. In no instance did instruction suffer appreciably when presented by television and in most cases the learning effectiveness was superior when television was used. This was particularly noticeable in certain types of instruction. The "how-to-do-it" type, such as the assembly or disassembly of a weapon, and instruction incorporating the "cue and response" technique, such as used with the phonetic alphabet, were particularly effective (Fig. 2).

However, straightforward factual presentation, as with the subject of Military Justice, did not show any significant difference between television and live instruction.

One very important fact demonstrated in this phase of the study was the effectiveness of television in teaching lower I.Q. trainees. The students were divided according to their I.Q. and results were compared between the upper and lower 50%. It was found that in the upper 50% there was no significant difference in the learning effectiveness between live- and television-presented instruction. However, with the lower 50%, the degree of difference in favor of television was considerable in certain types of instruction. This is particularly important, as the more difficult training problem is presented by lower I.Q. groups.

The second phase of the study started in January 1954 and was completed 30 June 1954.

The second phase had three definite requirements:

1. An extension of the television evaluation to other subject matters to include both basic and technical subjects so as to develop criteria based on both Phases I and II, which may be used as a basis for future utilization of television as a training medium.

2. An evaluation of learning effectiveness brought about by changes in viewing and studio equipment. It is the desire to come up with a basic package, capable of handling most training problems, yet a package that will facilitate expansion or modification to meet specialized requirements.

3. An evaluation of learning effectiveness brought about by controlled changes and/or abbreviations in lesson plans. In other words, can television be used to decrease the length of time devoted to training military personnel? The Army is faced with training many people as rapidly as possible and any

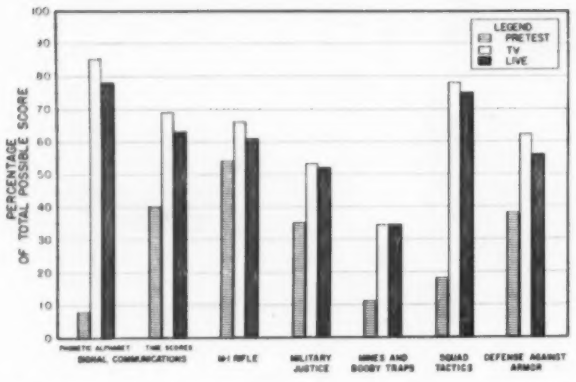

Fig. 2. Comparison of TV-live conditions for primary companies.

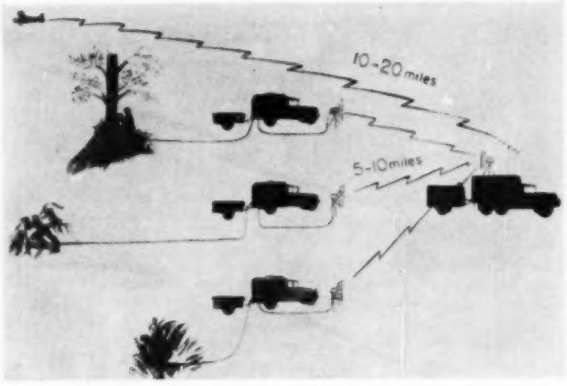

Fig. 3. Signal Corps Interim Tactical TV System flow chart.

time that can be saved without a loss of training effectiveness is desirable.

Preliminary comparisons have shown that time *can* be saved by eliminating such common items as walking from one training aid to another, writing on the blackboard, etc. By using television cameras and eliminating these factors, it was possible, in certain types of instruction to reduce class time by as much as 40%.

As a part of the study, evaluations have been made on the use and application of television film recordings.

Television as a supplementary film production facility offers the Signal Corps an additional, relatively inexpensive and rapid means of producing certain types of films. Many training requirements exist for films of a specialized nature which are particularly susceptible to production by television, and where any possible quality loss through the kinescope process is fully acceptable. Also, one of the major problems involved in maintaining the efficient operation of any training installation is the change, loss and replacement of qualified instructor personnel. Straight film recordings of the important hours of training can provide a valuable aid to new or replacement instructors and can be used as a substitute whenever an instructor is lost. Furthermore, in the event of complete mobilization, these recordings could save the Army critical training time.

Although final results of Phase II have not yet been published, the Signal Corps is currently incorporating the results of both phases in Army television training programs as rapidly as the information becomes available.

Tactical Television

Since the first wars were fought, military leaders have been hampered by their inability to see what was taking place on the battlefield. Plans had to be based on fragmentary and often contradictory reports from scouts and patrols. Control during the actual battle presented even a greater problem, with success left in the hands of the small unit commanders. With the slow, steady development of battlefield communication systems, starting with signal flares and flags and progressing to telegraph, telephone and radio, some measure of control was possible and the commander was able to form a picture, not always accurate, of the local and overall situation. His picture, of necessity, depended upon the experience, judgment and interpretation of many, and was sometimes hours and even days old by the time it reached him. In the future of television may lie the answer, *the ability to see immediately and control the battle situation.*

Some of the tactical applications explored by the Signal Corps Mobile TV Unit have been the use of television for:

1. Location, evaluation and designation of artillery targets, and adjustment and control of artillery fire.
2. Data transmission.
3. Intelligence and reconnaissance work.
4. Briefing of tactical commanders.
5. Observation and control of amphibious landings, river crossings and assaults.

This exploratory work substantiated the theory that small, miniaturized tactically mounted equipment was desirable. However, again some further operational research was indicated. Therefore, based on what had been learned from the work of the Mobile Unit, the Signal Corps devised an Interim Tactical Television System, utilizing commercially available equipment capable of simulating the concept of tactical television. A concept which embraces the idea of an integrated television system consisting of specialized television facilities.

The Interim Tactical TV System consists of three hand-held television cameras operating out of $\frac{3}{4}$-ton trucks (Fig. 3).

The signal from these cameras is microwaved back to a base station mounted in a $2\frac{1}{2}$-ton truck, which contains the control and monitoring equipment for the system. This base station can be located at a Regimental or Division Command Post. The airborne equipment mentioned earlier forms a part of this system and is received by the base station.

The Tactical System participated as an operational part of Exercise Flashburn, Fort Bragg, N.C., one of the Army's biggest maneuvers in 1954. There it operated as an intelligence gathering agency, for troop control and control of an armored attack, as a communications transmitting device, for air reconnaissance of enemy positions and movement, and for evaluation of captured enemy material.

The Interim Tactical Television System is scheduled for visits to such places as the Engineer, Infantry, Artillery and Armor Schools. During these visits it is being used to explore and evaluate television as it can be applied to the combat jobs of these Branches.

It is expected that the results of this work with the Interim Tactical TV System, as well as the results of the training studies, will form the basis for the future use of television in the Army and provide background for determining doctrine, policy, techniques, methods of operation, personnel and equipment requirements and will establish areas and fields of utilization and application of military television.

Cross-Modulation Tests, 16mm Variable-Area Photographic Sound, PH22.52-1954

This Standard was not published for trial and comment since the revisions were wholly editorial in nature: bringing references up to date and streamlining the title.

American Standard

Cross-Modulation Tests, 16mm Variable-Area Photographic Sound

ASA
Reg. U.S. Pat. Office
PH22.52-1954
(Revision of Z22.52-1946)

*UDC 778.5.620.1:621.396.619

1. Scope and Purpose

1.1 This standard describes the cross-modulation method of measuring high-frequency distortion introduced during the processing of 16mm variable-area sound motion-picture release prints. Through measurements of distortion at various print densities, it is possible to choose a print density which will give sound prints having minimum distortion and optimum quality under the particular method of processing employed.

1.2 Cross-modulation tests are used extensively in establishing and maintaining photographic control of variable-area soundtracks. In consideration of waveform, output level, and noise reduction, it is necessary for variable-area prints to have high density contrast. At satisfactorily high track densities an appreciable amount of image spread occurs, producing partial rectification of high frequencies. To compensate for this, an equal and opposite amount of image spread is introduced into the negative. Therefore, to establish the correct negative and print density combination, amplitude-modulated high frequencies are recorded and printed over a suitable density range. By measuring the rectified component from the prints, the correct density combinations are indicated.

2. Test Method

2.1 The test track, described in 2.3, is recorded and developed under standard conditions for the process being checked. A series of prints is then made at suitable printer lights to give a range of print densities for unmodulated, unbiased tracks above and below the expected optimum density. In most cases this will be in the density range from 0.8 to 1.7. There should be sufficient unspliced film ahead of the test track to permit stabilization of printer speed. The distortion content of the test-track print is then measured using equipment as shown in Fig. 1.

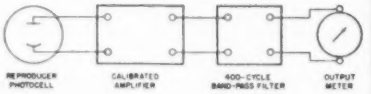

Fig. 1. Basic Arrangement of Cross-Modulation Test Equipment to Determine Distortion on Test Track

In making the measurements, the test-track print is threaded through the soundhead of the film reproducing device in the proper manner according to the position of the soundtrack. The distortion of each section of the print is then measured according to the operating instructions for the cross-modulation meter used if one is available.

2.1.1 If measurements are made using individual pieces of equipment, as shown in Fig. 1, the gain is adjusted to 0 db output reading on the 400-cycle section of the test track, so that the output meter will properly read the db output from the 4000-cycle section of test track, which is modulated by the 400-cycle signal. The difference in output for the 2 sections of the cross-modulation test track is the cross-modulation for the process being checked.

2.2 Since the method here described measures the over-all distortion for a process involving numerous variables, each of which may affect the total distortion, it is necessary that all such variables (except the print density which is purposely varied to find the optimum) in the recording and processing of the test track be maintained at the same values as they are normally in the process to be checked. These variables include film stock (both sound negative and print), recorder-lamp current, negative gamma, color temperature of printer light, and type of printer (contact or optical).

2.3 Test Track. The test track consists of 3 sections, recorded in sequence at the same lamp-current setting:

2.3.1 ***Section 1.*** 400 ± 10 cycles constant amplitude at 2 ± ½ db below full modulation.

2.3.2 ***Section 2.*** 4000 ± 200 cycles amplitude modulated 2 ± ½ db below full modulation at 400 ± 10 cycles. The peak amplitude of this modulated wave shall be 2 ± ½ db below that required for full modulation of the soundtrack.

2.3.3 ***Section 3.*** Unmodulated, unbiased track, or track fully modulated at approximately 30 cycles, or less, for density measurement.

2.3.4 Sections 1 and 2 should have a running time of 10 seconds and section 3 at least 1 second. Neither the 400- or 4000-cycle waves shall contain more than 5 percent harmonic distortion. The modulated wave of section 2 must not contain a 400-cycle component greater than 50 db below the average 4000-cycle amplitude of the modulated wave. The recorder should be correctly adjusted for slit azimuth, track location, and focus.

Note: This test track should also be used in the case of 35mm negatives prepared for a study of optical reduction printing, instead of the tracks commonly used in checking regular 35mm print production.

Approved August 13, 1954, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

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3. Test Equipment

3.1 Reproducing Equipment. The reproducing equipment shall consist of a 16mm sound film reproducer, amplifier, 400-cycle band-pass filter and volume indicator.

3.2 Amplifying System. The amplifying system should have approximately 110 db gain and should be adjustable in 1 db steps over a range of 40 db. When the modulated wave described in 2.3.2 is applied to the input of the amplifier at sufficient amplitude to produce normal output, the 400-cycle component of the amplifier output shall be at least 50 db below the average 4000-cycle amplitude of the same modulated wave. The gain of the amplifying system shall be calibrated at 400 and 4000 cycles. The relative gain at these frequencies shall vary not more than ± 1 db for any setting of the gain adjustment. The attenuation of the 400-cycle band-pass filter shall vary not more than ± 0.5 db between 375 and 425 cycles and shall be at least 50 db at 4000 cycles.

3.3 Distortion. Care should be taken that the reproducer photocell and its associated coupling circuit to the amplifier input tube do not introduce a significant amount of cross modulation. The complete reproducing system should be checked for indications of distortion by use of a suitable test film when available.

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J. O. Baker and D. H. Robinson, "Modulated high-frequency recording as a means of determining conditions for optimal processing," *Jour. SMPE*, 30: 3–17, Jan. 1938.

Dorothy O'Dea, "Comparison of variable-area sound films," *Jour. SMPE*, 45:1–9, July 1945.

News and Reports

Section Meeting

The opening meeting for the 1954–55 season of the **Central Section** was held on Monday, September 20, in the Western Society of Engineers auditorium in Chicago. Prior to the meeting the Central Section officers and Board of Managers met to discuss finances, papers and general administration. Since the meeting night has already been changed to Monday at the request of the members, it was decided to take a vote at the current meeting to see if an earlier starting time would be of benefit to the majority.

A pre-meeting dinner was held at Stouffer's Restaurant and was unusually well attended.

Lawrence S. H. Hanchek, President of Film Services, Inc., in Chicago, gave a paper on "Television Newsreel Techniques," which was the entire evening's program. Mr. Hanchek is well qualified on the subject of television news, since he operates a laboratory which services local television stations in the Chicago area. This presentation covered news production from camera to projector. At the conclusion of his talk, Mr. Hanchek ran two reels of 16mm positive prints illustrating typical news shots of all kinds.

The next meeting of the Central Section will be held on Monday, November 15.—*K. M. Mason*, Secretary-Treasurer, 137 N. Wabash Ave., Chicago 2.

The Calvin Workshop

When the first Calvin Workshop was scheduled in November of 1947 we expected, or rather hoped, that 20 or 30 people might show up. We had 125. The next year the attendance jumped to 240.

The most recent Workshop was held in April of 1954 and we assumed the attendance would be somewhere near our seven-year average of 250. We had slightly over 400 people. We will schedule our ninth annual 16mm motion-picture production Workshop for sometime in March or April of 1955. We think we might have 250 people, or maybe 300, or maybe 400 — but we no longer make any forecasts!

We planned our first Workshop back in 1947 on the assumption that there were hundreds or thousands of people who had become newly acquainted with the value of visual aids during the war years, that many of them were going into the film-production business, but that comparatively few of them could be called experienced film producers. We thought that we might contribute something to an apparent need by opening our building to any one interested — so that they could see the facilities required in film production and laboratory work. Further, by discussing the business of producing pictures and illustrating our points on the screen we thought these same people might be provided with the opportunity of learning from our own experience, and from our own mistakes. As worded in our first program folder, "the purpose of the Workshop is to consider basic and factual material through the utilization of exhibits, demonstration, and discussion. The Workshop is for the men and women engaged and interested in the production of educational, religious, and commercial 16mm motion pictures."

Right from the beginning it was apparent that, more or less accidentally, we were filling a need. Each year since 1947 these hundreds of film people have come to Kansas City to be with us for the Workshop — representing all sizes and phases of motion-picture activity, coming from all sections of the nation as well as from other countries, sitting through every session for the three full days and three full nights, and with only about 20% of one year's group in the next year's attendance. In other words, about 80% of each Workshop attendance are people who have not been with us before. Where do they come from? Well, this year from 33 States and two Canadian Provinces. In the past, also from Thailand, England, Iran, Cuba, and Washington, D.C. We have had representatives from the film departments of all three Armed Services as well as from the Departments of Agriculture, Commerce, Interior and State—from colleges, universities and museums — television and industrial producers — the film departments of industry and church — and from many business and industrial firms.

Some are beginners, others are thinking about getting into the film business, still others have been producing for years. Some are film buyers who want to find out what work is represented behind the purchase orders they make out and approve. Still others have never and will never produce a film but they want to know something of the standards involved in production as an aid to forming their own standards in buying and using films.

We are still a little astonished at the numbers of new people who are with us each year. Of course, we can't be sure of the reasons why they come, but we do have some theories.

Beginning with the first Workshop we have operated on the basis of certain policies:

(1) To restrict the main subject matter to the business of producing 16mm motion pictures, with other special sessions on allied interests.

(2) To keep the *talk* about pictures to a minimum and to *project* a maximum of film scenes or sections or complete films to illustrate the points under discussion.

(3) To schedule the individual Workshop sessions in the order of the normal steps followed in producing motion-picture film, starting with the script and working right on through to the release prints.

(4) To be straightforward in utilizing our material to the best advantage in illustrating the problems of film making, and to try to eliminate any and all obvious sales pitches. (We realized that this approach would prove to be better salesmanship as well as better taste!)

(5) To open the Workshop to any one interested in film production, without fee or obligation — and to competitor as well as to "prospect."

(6) To hold back nothing in the way of "trade secrets" regarding either equipment or methods. (We don't put much store on trade secrets. What you do with what you have is what counts.)

We believe that these policies have proved to be good choices, and that they have made the Workshop attractive to film people. In addition, we have been most fortunate in having as our guest speakers some of the outstanding men in the business, from manufacturing, producing and utilization circles.

It may be that the main appeal of the Calvin Workshop lies in the fact that it provides what has been termed a capsule course in film production, does so in simple language and with considerable screen illustration, and, through its guest speakers and exhibits, keeps abreast of the new developments. The comments of Workshop guests are unanimous in stating that the Workshop provides them their only opportunity to study the entire operation of film production from start to finish, on a practical, up-to-date workaday basis. They also tell us that they find their Workshop Notebook the most complete and modern "Text Book" on the subject. So, these must be among the reasons why they come.

The people who do come certainly come to talk shop and not for the usual convention "relaxation." They are on hand the first thing each morning and they don't leave until the last end title leaves the screen around ten or eleven o'clock at night.

We have now sponsored eight Workshops, and we're learning how to do it a little more easily. But we still have a good deal of preparatory work each year, espe-

SMPTE 76th Convention

Ambassador Hotel, Los Angeles

Committee Meetings

TUESDAY—October 19
- 10 A.M. Papers/77th Convention, location to be announced
- 10 A.M. PH22, Regency Rm
- 2 P.M. Sound, Regency Rm

WEDNESDAY—October 20
- 10 A.M. Film Projection Practice, Regency Rm
- 2 P.M. Color, Regency Rm
- 2 P.M. High-Speed Photography, location to be announced

THURSDAY—October 21
- 10 A.M. Television, Regency Rm
- 2 P.M. Magnetic Recording, Regency Rm
- 8 P.M. Laboratory Practice, Regency Rm

FRIDAY—October 22
- 10 A.M. Screen Brightness, Regency Rm
- 2 P.M. 16 & 8mm, Regency Rm

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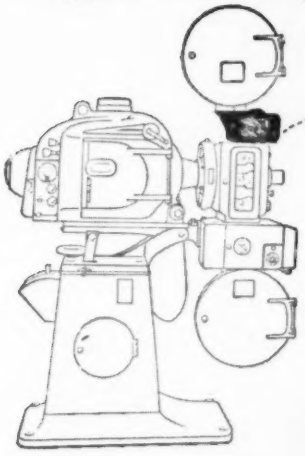

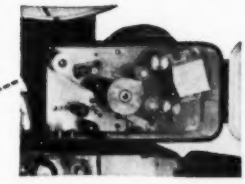

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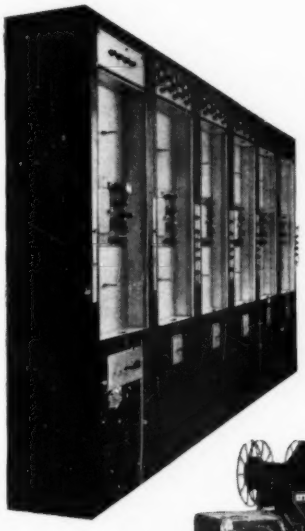
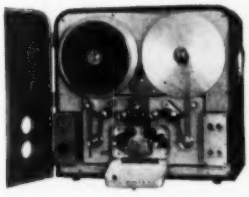
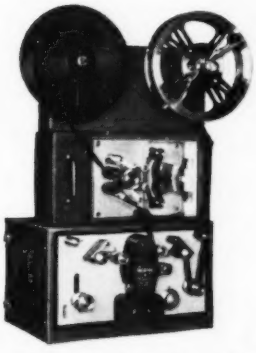
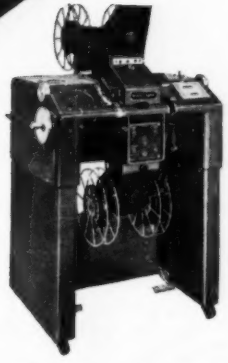


Westrex Electrical Printer simultaneously makes duplicates of original four-track magnetic recordings as required by individual studios.



Westrex RA-1517B Stereo-Recorder, with its very low flutter content and high volume range and signal-to-noise ratio, is today's quality portable triple-track stereo-magnetic recorder





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cially in the month preceding the Workshop dates. We are all a little worn down by the end of the Workshop week. But what started as an experiment and is now often referred to as an "institution" we consider a very valuable activity — and we deeply appreciate the annual opportunity thus provided to show our facilities to our guests and to become personally acquainted with so many friends, both old and new.

Some years back we discovered that our annual question, "Shall we have a Workshop this year?" had somehow changed to "When shall we schedule the Workshop this year?"—*Neal Keehn*, The Calvin Co., 1105 E. Truman Rd., Kansas City 6, Mo.

Book Reviews

Film Technique and Film Acting

By V. I. Pudovkin. Translated by Ivor Montagu. Introduction by Lewis Jacobs. Published (1954) by Vision Press (London) Ltd. Distributed in the U.S. by The British Book Centre, Inc., 122 E. 55 St., New York 22. 384 pp. 24 illus. 5 × 7½ in. $4.50

Ever since their original publication abroad over twenty years ago, these two books by the notable Soviet director have been justly considered as the basic landmarks of cinema theory and practice.

Despite the many changes, technical and esthetic, that film has undergone, this remains true even today; for instance, Pudovkin's remarks about the 1930 Fox Wide Film experiment fit perfectly the new aspect ratio of our screens.

The professional film maker as well as the serious student of the movies will richly profit from an attentive perusal of this exceptional work.—*George L. George*, Screen Directors Guild, New York.

A Guide to Film Services of National Associations, issued by the Film Council of America, 600 Davis St., Evanston, Ill., at $2.00 per copy, is a two-hundred page, paper-bound book which describes the activities of 134 organizations and how they use, and distribute, 16mm films.

A Directory of 2,660 16mm Film Libraries has been published by the Government Printing Office, Washington 25, D.C., from which it may be ordered for 50¢. Arranged alphabetically by cities within the States, the annotations of each of the 2,560 libraries tells the number of films available, the nature of the pictures, and the restrictions, if any, on distribution.

Noise Control is a new magazine being prepared by the Acoustical Society of America for bimonthly issuance beginning in January 1955. It will cover problems arising, among other places, in the entertainment field as well as building construction, and the first issue will include articles such as "Measuring Noise," by George Bonvallet of Armour Research Foundation; "Reduction of Noise in Machines and Vehicles," by R. O. Fehr and R. J. Wells of General Electric; and "Fundamentals of Noise," by A. C. Pietrasanta of Bolt, Beranek and Newman, Inc. One article will discuss reduction of noise outdoors, while another will cover reduction of noise indoors; and features will include news items from major newspapers, short case histories of noise reduction, announcements of new products and book reviews. Editor of the new magazine is Lewis S. Goodfriend, 57 E. 55 St., New York 22. Subscriptions to Noise Control for members of the Acoustical Society are $5.00 a year; to nonmembers, $8.00 in U.S., Possessions, Canada and Mexico; $10.00, elsewere.

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer
vol. 35, Mar. 1954

A New Instrument for Checking the Focus of Camera-mounted Lenses (p. 129)

Shooting A Newsreel-type Production in Color (p. 130) *R. W. Luce*

Organizing a TV Film Production Unit (p. 134) *M. Agnello*

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Filming the Everest Climb (p. 138) *A. L. Marble*
Video Tape Recording and Home Movies (p. 142) *R. J. Berry*

vol. 35, Apr. 1954
Tomorrow's Wide-Screen Camera (p. 174) *A. E. Gavin*

vol. 35, May 1954
Follow-Focus Attachment for Mitchell Cameras (p. 237)

vol. 35, June 1954
Hollywood's Greatest Underwater Venture (p. 282) *T. Gabbani*
Light Plays a Part in Set Design (p. 286) *W. B. Mellor*
The Pre-editing Stage (p. 288) *C. Loring*
The Cinerama Technique (p. 290) *J. Brun*

Audio Engineering

vol. 38, Apr. 1954
Stereophonic Reproduction (p. 21) *R. Vermeulen*

Handbook of Sound Reproduction, Chapter 18. Testing and Measurement (p. 26) *E. M. Villchur*

Bausch & Lomb Magazine

vol. 29, No. 1, 1954
Stereoscopic Motion Pictures and Binocular Visual Performance (p. 4) *R. A. Sherman*

Bell Laboratories Record

vol. 32, July 1954
Continuous Scanner for Televising Film (p. 250) *R. E. Graham*

Bild und Ton

vol. 7, Feb. 1954
Die Bildstandsfehler bei der Wiedergabe und ihre Ursachen (p. 34) *K.-O. Frielinghaus*
Entwicklungsstand der Bildprojektoren und Bildtonanlagen für 16-mm-film in der Sowjetunion (p. 40) *G. Pierschel*

vol. 7, Mar. 1954
Das Kettenblendenband, ein neues Hilfsmittel im Agfacolor-Kinefilm-Kopierprozess (p. 66) *A. Clever*
Zur Kenntnis der Farbentwicklung (p. 69) *K. Meyer*

vol. 7, May 1954
Die günstigste Ausführung des Bildschnittes beim 8-mm-Schmalfilm und die Konstruktionsmerkmale einer entsprechenden Klebepresse (p. 154) *P. Sarzesny*

British Institution of Radio Engineers, Journal

vol. 13, Sept. 1953
Economy of Bandwidth in Television (p. 447) *D. A. Bell*

British Kinematography

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Filming the Everest Expedition (p. 36) *T. R. Stobart*
The Duplicating of 16mm Colour Films. Standard Contact Printing of Kodachrome (p. 43) *R. G. F. Chase*

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Stereophonic Sound (p. 64) *A. W. Watkins*
Standardized Light Sources for Colour Photography (p. 72) *R. L. Hoult*
Practical Problems in the Projection Room (p. 82) *J. Parsons*

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The Television Outside Broadcast Unit (p. 96) *K. E. Owens and P. R. Berkeley*
Recording Television on Magnetic Tape (p. 111)

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Magnetic Recording of Television Signals (p. 124) *C. G. Mayer*
The Gevacolor Duplicating Process (p. 131) *L. Meeussen*

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Technical Aspects of Italian Film Production (p. 151) *P. Cavazzuti*
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vol. 2, Apr. 1954
Color TV Receiver Tubes (p. 20)

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Signal Overload Relay for Television Receivers (p. 153) *C. Masucci, J. R. Peltz and W. B. Whalley*

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Color Demodulators for Television Receivers (p. 164) *E. G. Clark and C. H. Phillips*
TV Lighting Calculator (p. 192) *J. Sodaro*

vol. 27, July 1954
Television Flying-Spot Slide Scanner (p. 134) *A. J. Baracket*

Ideal Kinema

vol. 20, May 13, 1954
More Light on Big Screens, Reflective Characteristics Examined (p. 13) *R. H. Cricks*
Anamorphic Lenses Explained (p. 15)

vol. 20, June 17, 1954
Anamorphic Projection without Distortion (p. 13) *R. H. Cricks*
Polaroid's Vectograph—The System That Puts 3-D on to One Film (p. 14)

Industrial Finishing

vol. 30, Apr. 1954
Metallizing TV Picture Tubes (p. 45) *J. M. Lupton Co.*

Institute of Radio Engineers, Proc.

vol. 42, July 1954
IRE Standards on Television: Methods of Measurement of Aspect Ratio and Geometric Distortion, 1954 (p. 1098)

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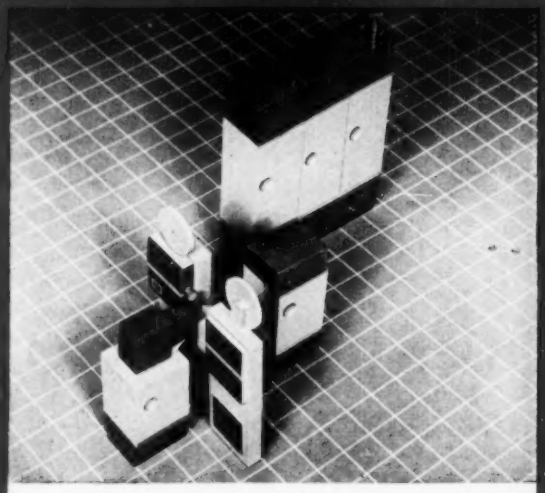

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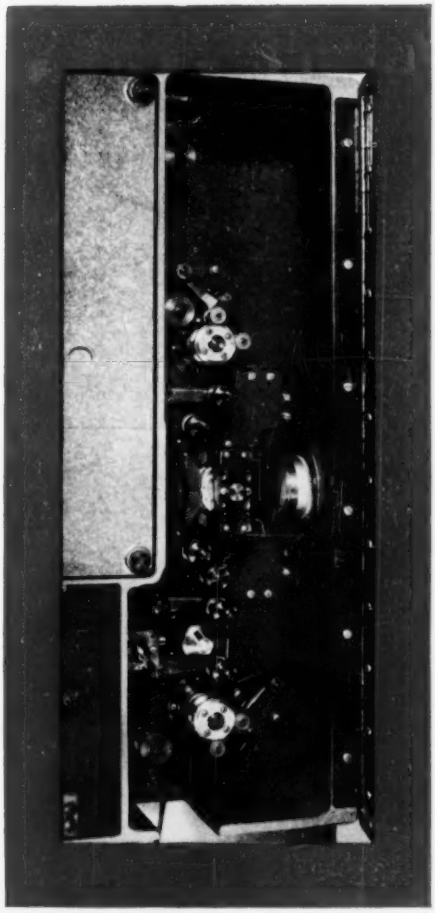
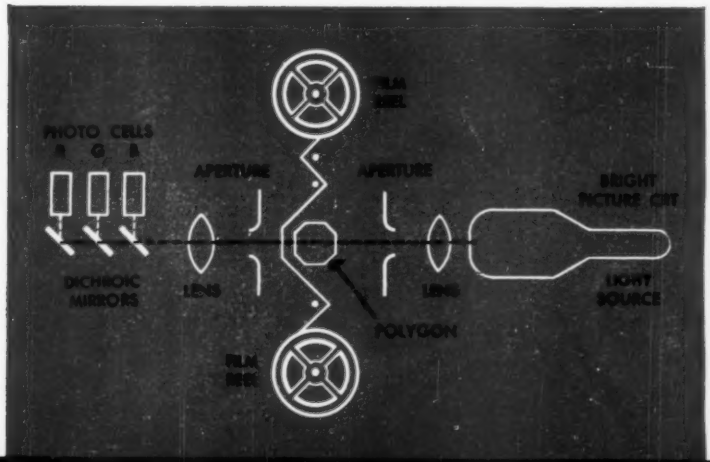


Interior view of the film unit showing precision film transport mechanism, sound head and the simplicity of the optical system.



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IRE Standards on Audio Techniques: Definitions of Terms, 1954 (p. 1109)

International Photographer

vol. 26, May 1954

VistaVision Camera (p. 16)

International Projectionist

vol. 29, Mar. 1954

Simple "Degaussing" Procedure Protects Magnetic Tracks (p. 10) *E. Stanko*

World's Premiere Theatre Adopts "Flat" Screen for ALL Film Showings (p. 16) *C. Muller*

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Paramount's VistaVision (p. 13) *L. L. Ryder*

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The Anatomy of CinemaScope (p. 7) *R. A. Mitchell*

VistaVision: Promise of Sanity (p. 11)

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RCA's Portable 16-mm Arc Projector (p. 16) *J. J. Hoehn, A. J. Cardile and R. A. Wood*

From Muybridge to CinemaScope (p. 22) *J. Card*

Kino-Technik

vol. 8, Apr. 1954

Series of illustrated, descriptive articles on Agfa, Arnold & Richter, Askania-Werke, Bell & Howell, Bernhard Deltschaft, Andre Debrie, Frieseke & Hoepfner, C. Conradty, Gevaert, C. Jost, Kino-Bauer, Linhof, K. G., J. D. Möller, Niezoldi & Kramer, Perutz, Schneider, Siemens-Klangfilm, C. Zeiss and Zeiss-Ikon.

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VistaVision—Breitwandverfahren mit grossem Negativbild (p. 178) *W. Beyer*

Die optischen Grundlagen des Garutso-Verfahrens (p. 179) *H. Atorf*

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Kritische Betrachtungen des CinemaScope-Systems (p. 184) *G. Heinecke*

Motion Picture Herald

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MGM, Paramount Films Use Perspecta Sound (p. 12)

Superscope Comes East in Impressive Debut (p. 14) *V. Canby*

vol. 195, no. 5, May 1, 1954

Paramount Presents "VistaVision" and New York's Industry Finds Bow Impressive (p. 12)

Motion Picture Herald (Better Theatres Sec.)

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Stereophonic Sound in the Development of New Techniques (p. 16) *G. Gagliardi*

Making Growth of the Art Complete With Stereophonic Sound (p. 17) *G. Schutz*

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VistaVision. The New Paramount System (p. 22) *L. L. Ryder*

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The Installation and Operation of a Perspecta Sound System (p. 21) *N. H. Crowhurst*

Anamorphic Versus Cropping in Wide-Screen Projection (p. 23) *G. Gagliardi*

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VistaVision Sound and Booth Operation (p. 21) *L. L. Ryder*

The Tushinsky Anamorphic System in Printing and Projection (p. 22) *G. Schutz*

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Wide-Screen Presentation at the Drive-In Theatre—with a "White" Screen Surface (p. 25) *G. Gagliardi*

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Eye Movements in Connexion With Television Viewing (p. 964) *M. P. Lord*

Philips Technical Review

vol. 15, no. 7, Jan. 1954

The Focusing of Television Picture-Tubes With Ferroxdure Magnets (p. 214) *J. A. Verhoef*

Photo-Technik und -Wirtschaft

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Magnetton-Vertonungsverfahren fur Schmalfilme (p. 348)

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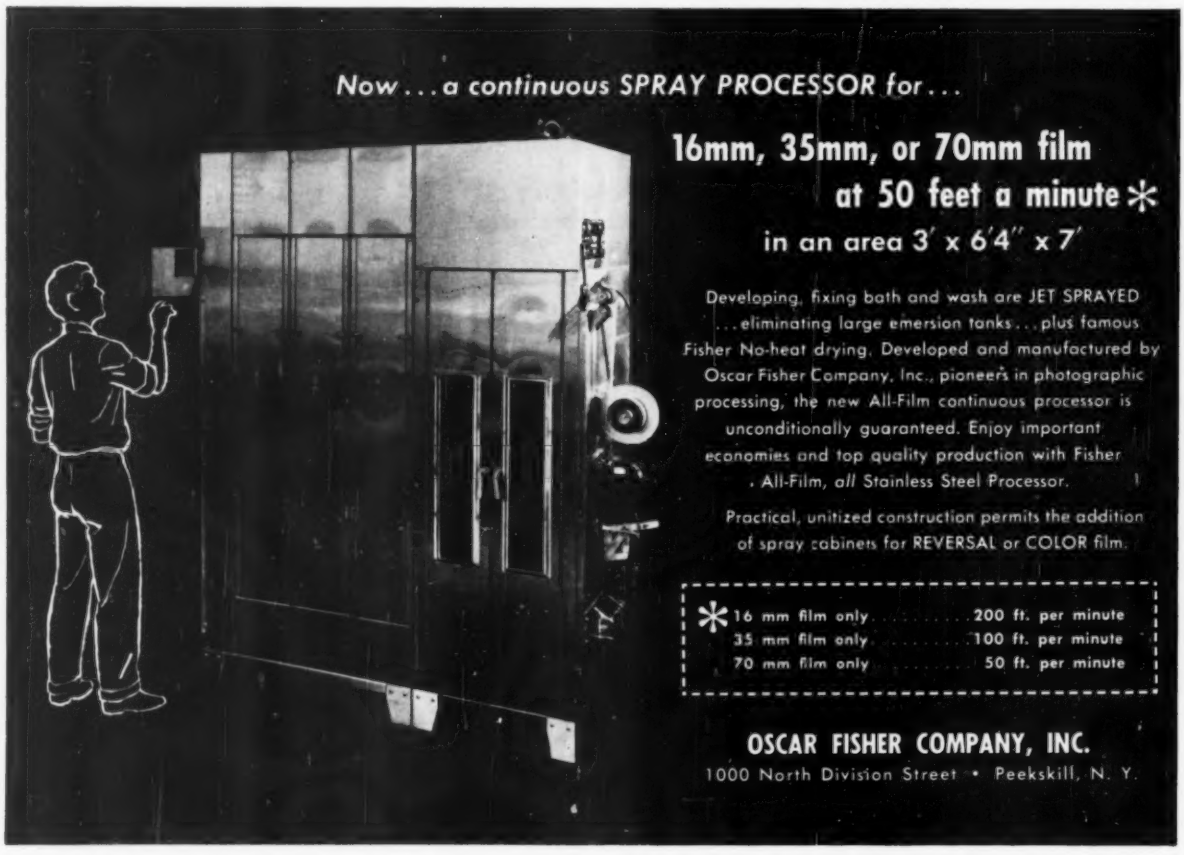
Was eine Schmalfilmkamera leistet: Agfa Movex 8 L (p. 352) *F. Frese*

Helle Projektionsbilder durch richtige Lichtführung (p. 356)

Lievin Gevaert begründete vor 60 Jahren eine Weltfirma (p. 358) *H. H. Grassmann*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Radio & Television News

vol. 51, May 1954

Fundamentals of Color TV. The Tri-Gun Receiver (p. 40) *M. S. Kiver*

vol. 52, July 1954

Magnetic Recording 1888 to 1954 (p. 59) *L. A. Wortman*

Fundamentals of Color TV Chrominance Circuits (p. 60) *M. S. Kiver*

RCA Review

vol. 15, Mar. 1954

A System for Recording and Reproducing Television Signals (p. 3) *H. F. Olson, W. D. Houghton, A. R. Morgan, J. Zenel, M. Artzt, J. G. Woodward and J. T. Fischer*

Investigation of Ultra-High-Frequency Television Amplifier Tubes (p. 27) *W. Y. Pan*

vol. 15, June 1954

The Metrechon—A Halftone-Picture Storage Tube (p. 145) *L. Pensak*

Synthetic-Pattern Generator for the Solution of Certain Instrumentation Problems in Television (p. 187) *R. C. Webb*

Tele-Tech and Electronic Industries

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Compatible Color Signal Content and Transmission (p. 80) *E. S. White and M. H. Kronenberg*

New Test Tape for Magnetic Recorders (p. 88) *J. A. Konins*

RCA's New 19-Inch Color Tube (p. 168)

vol. 13, May 1954

Vari-Focal TV Lens (p. 87) *J. Radick*

New Color Stripe Generator for TV Stations (p. 122)

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Bibliography of Magnetic Recording 1900-1953 (p. 54) *A. Jorysz*

Tape and Disc Recording System (p. 65) *C. K. Chrismon*

U. S. Camera

vol. 17, July 1954

Report on Magnetic Sound (p. 83) *M. T. Astroff*

Westinghouse Engineer

vol. 14, May 1954

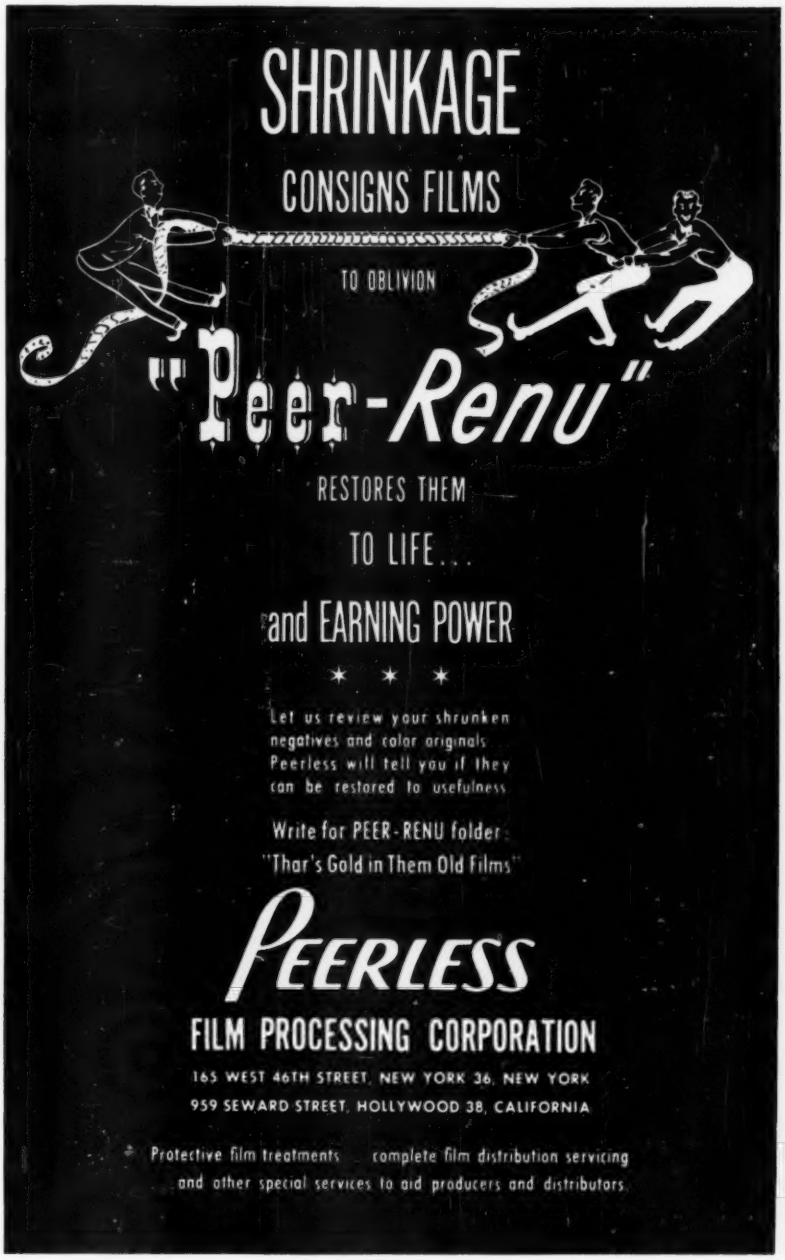
Color Television (p. 98)

Obituaries

Terry Ramsaye, film historian and one of the best-known pioneers of the motion-picture business, died August 19 at Norwalk, Conn., aged 68.

Mr. Ramsaye was born in Tonganoxie, Kansas, and studied engineering at the University of Kansas. He worked briefly in the engineering department of the Bell Telephone and Western Electric Companies before going into newspaper work as a reporter for the Kansas City Star and Times. As his journalistic career progressed, so did his interest in motion pictures, and as a reporter for the Chicago Tribune he later combined the two by collaborating with the late Moses Annenberg in promotional efforts that resulted in a series of stories on the then popular motion-picture serials.

In 1914 he entered the motion-picture industry as an editor and producer. Some of his early experience was gained in the Edison studio then located in the Bronx, where he produced a great many short entertainment films including some with sound recorded on disks. As publicity and advertising director of the Mutual Film Corp. he founded the Screen Telegram, a newsreel that had notable success during World War I. After producing and editing patriotic shorts for the Treasury Department, a number of scenic and travel films, including Martin Johnson's *African Hunt*, and a session as editor in chief of Pathe News and Pathe Audio Review, Ramsaye joined the Motion Picture Herald as editor in 1931. From then until 1950 when he became consulting editor to the Quigley Publications, he was very active and was widely known through-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out the industry for the incisiveness with which he conducted the Herald's affairs. Throughout his editorial career, he never lost sight of the closely knit and uniquely standardized technical foundation on which the motion-picture industry securely rests, and he gave continuous support to the engineers and their work.

Terry Ramsaye is perhaps best remembered for his history of the beginnings of the motion-picture business *A Million and One Nights*. This two-volume book, which was compiled during the period from 1920 to 1925, contains a great wealth of anecdotal material about the early days and has become a standard work of reference. He was a Fellow of this Society. He last addressed the Society at the Convention at Lake Placid in 1950.

Arthur W. Carpenter, one of the earliest members of the Society, died July 17th at Fort Knox, Kentucky. He was 63 years old.

Dating from his early experience as a research photographer and radiographer at the Massachusetts Psychopathic Hospital, Arthur Carpenter was long active in the field of medical and scientific photography. For some years he had been associated with the Army Medical Research Laboratory at Fort Knox, where his latest position was as Roentgenological and Radiations Scientist.

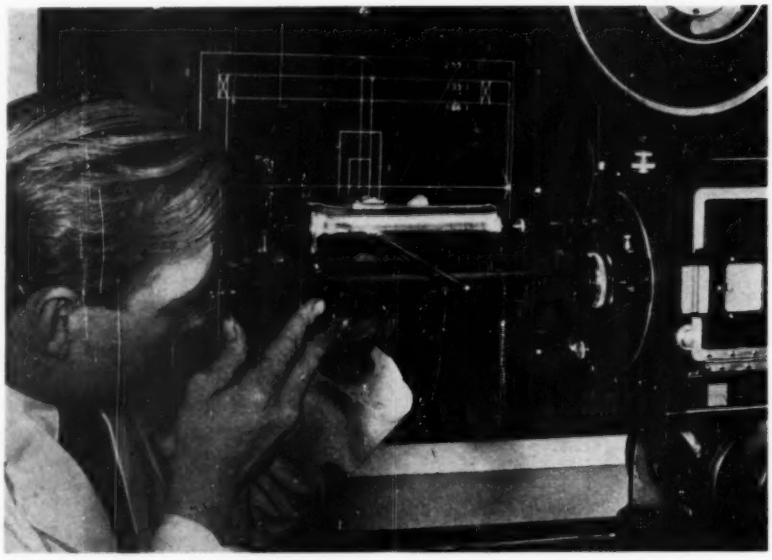
At the Fall 1953 Convention of the SMPTE, in Washington, D.C., Arthur Carpenter was one of the Society's pioneers honored at a special dinner, and the recipient of a certificate commemorating his long and distinguished membership in the Society.

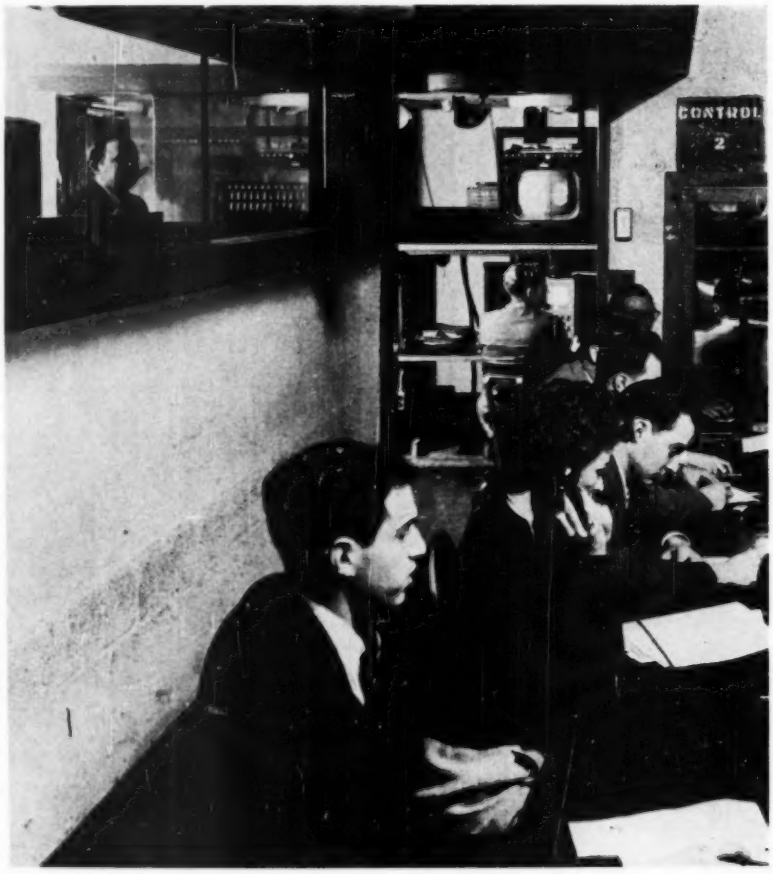
New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

The Taylor-Hobson Camera Focus Autocollimator is a new studio instrument announced by Taylor, Taylor & Hobson Ltd., 37-41 Mortimer St., London W.1. Whenever rough handling or temperature changes may have shifted the lens with respect to the film to make the focusing scale inaccurate, the Autocollimator permits setting the camera lens in a focus at infinity. The instrument provides an infinitely distant image of an illuminated graticule which can be picked up by the camera and focused on the film plane, thus establishing a true infinity focus. Any error then in the focusing can be eliminated by correcting the fiduciary mark. The instrument consists of two systems built in one body, the projector system, or collimator, and the viewing system or telescope.

With standard ¼-in. (×20) eyepiece, and setting on film emulsion, the Camera Focus Autocollimator is suitable for checking camera lenses between 1-in. and 8-in. focal length. For camera lenses below 1-in., which give rise to high magnification of the film emulsion, a lower power eyepiece will be available. Detailed information about accuracy and application is available from the manufacturers.





In Du Mont's new Tele-centre at 205 E. 67 St., New York, all five studios have isolated unit control rooms, such as shown here. The production unit, on the lower level, is separated by glass partitions from the video unit (rear, lower level) and the audio and lighting unit (upper level).

All five control rooms are located in a vertical bank with cables tieing in a straight line to the master control, providing the shortest possible run, to enhance the quality of picture and sound. Film projection facilities on the second floor include the Du Mont Multiscanner, which is adapt-

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able to color, and they can be remotely controlled from each studio and from master control. On the same floor are kinerecording facilities including four units using a double-system technique for recording "live" shows for later distribution.

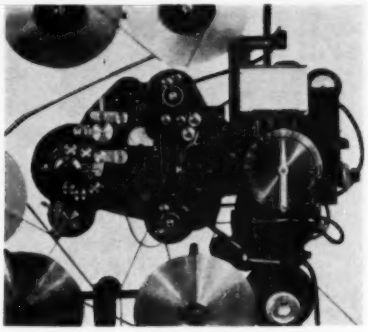
The Tele-centre's five major studios include one which is the largest in the East, 110 by 80 ft. in area and 40 ft. high. The $5,000,000 Tele-centre has been built within the seven-floor building built by Jacob Ruppert in the 1890's to be the Central Opera House which had besides the opera house, several small theaters (later used for motion pictures), restaurants, bars, bowling alleys, a swimming pool and several living apartments — a total of 2,500,000 cu.ft.

Control facilities, shown at the right in the above photograph, have been added to the Model 168 Beckman and Whitley Streak Camera which was described in detail under New Products, in the March 1953 *Journal*, p. 318. The control facilities are reported to make the unit a complete system for the synchronized recording of position-versus-time data. In use, the instrument makes a plot on a 4 × 10 in. film, where the vertical axis represents space and the horizontal axis represents time.

There are in the console facilities for the remote operation and monitoring of the event under study. Safety lights on the panel board indicate readiness for firing. When the firing button is pressed (a) the mirror starts; (b) the shutter opens; (c) Sync-Tac synchronizing tachometer fires the event at the selected speed and proper angulation of the mirror to begin the trace at the chosen position on the film; (d) the shutter closes; and (e) the mirror shuts off.

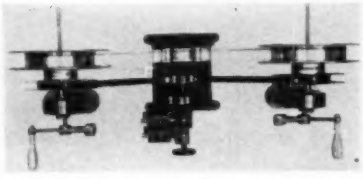
Synchronization is accomplished by a pulse-delay network which provides a voltage pulse for firing the event within a maximum of 0.6-μsec variation of the time required to position the image at the selected point on the film, with a ±0.2% speed synchronization accuracy. Adjustments at the camera provide for the known time delay between the firing pulse and the beginning of the event.

Further detailed information about the control features may be obtained from Beckman & Whitley, Inc., 945 E. San Carlos Ave., San Carlos, Calif.



A sound unit attachment for Models D and J Bell & Howell Contact Printers is manufactured by the Motion Picture Printing Equipment Co., Skokie, Ill. All holes in the sound unit are the same dimensions as in the original cover, so when the original printer gear-housing cover is removed, no drilling or fitting is necessary. The unit is driven by the printer. The lower printer feed-out sprocket is fitted with an additional gear mounted on a pivot arm, which intermeshes with the gear on the printer feed sprocket. The soundtrack is printed on a stainless steel drum which is ground and polished and mounted in Barden precision ball bearings.

The printing lamp in the printing drum is a 25-w, 115-v miniature bulb. Two aperture openings, one 1/16-in. and one 3/32-in., are provided. A d-c ammeter and an Ohmite rheostat control the lamp circuit. The sound unit film take-up has a torque take-up motor with an Ohmite rheostat wired into the circuit for tension adjustment.



The S.O.S. Differential Rewind Gimmick is being marketed by the S.O.S. Cinema Supply Corp., 602 W. 52 St., New York 19. The "Gimmick" is designed to rewind 16mm and 35mm reels simultaneously with uniform "take-up." The "Gimmick" is

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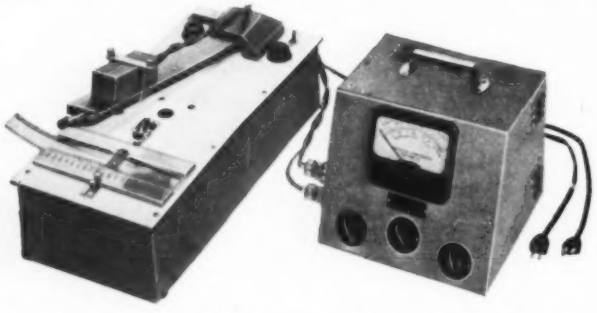
Sound-Track Densitometer
for measurement of density on sound track of 35mm and 16mm motion picture film and for evaluation of sensitometric step-tablets



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Write for Bulletin No. 245 Price, complete $445
The instrument is also available with Multiplier Photometer Mod. 520-A (additional price $230) for color densitometry with sharp-cutting narrow-band interference filters
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placed on a keywayed rewind spindle and regardless of the sizes of rolls or widths of films will not require the operator to throw slack. The film synchronizer can go backward or forward at will and the reels will be properly balanced.

Employment Service

These notices are published for the service of the membership and the field. They are inserted for three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Motion Picture Production. Desire position as assistant to producer. Background includes camera experience, some directing in 35mm productions. Age 24. Write: Harry Wuest, 137 Summit Ave., Upper Montclair, N.J.

Electronic Engineer. 20 yrs experience in all phases of audio; responsible for prominent part in development of the Perspecta stereophonic system; comprehensive experience in technical education, classroom, laboratory and the preparation of textbooks and technical literature; advanced training in economics and industrial administration; many responsible posts held. British born, came to U.S. July 1953. Active member I.E.E., I.R.E., A.E.S., SMPTE. Seeks progressive position in West. Write: Norman H. Crowhurst, 150-46 18th Ave., Whitestone 57, N.Y.

Positions Available

Motion-Picture Laboratory Technician (Sensitometry), GS-8, $4620 per year. Applicants must have at least 4½ years experience in all phases of motion-picture film processing in black-and-white and color. Position requires ability to handle quality control in processing and to make recommendations for and assist in improving the product. Further information from MCGCER, Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Ohio.

Photographic Sales Technician. Require competent technician with at least two years' college chemistry and phototechnical school training or equivalent. Must have thorough knowledge of black-and-white, color, studio, and photofinishing techniques. Must show definite interest in sales and willingness to travel. Send brief resume, including approximate salary requirements, to Gerald G. Wood, Ansco, 29 Charles St., Binghamton, N.Y.

Laboratory Technician with years of experience and thorough knowledge of all phases of motion picture laboratory work—as assistant to plant superintendent. **Sensitometric Control Man** with thorough background and experience—full responsibility. **Sound Engineer** to maintain and operate magnetic and optical re-recording equipment. Applicants should contact: Herbert R. Pilzer, Circle Film Laboratories, Inc. 33 West 60th St., New York 23. Tel. Co 5-2180

35mm Motion Picture Service Men. Openings in this country and Europe; experience not required if engineering graduate or if experienced in similar field. Apply to Army & Air Force Motion Picture Service, Engineering Depot, Building 207-C, 4300 Goodfellow Blvd., St. Louis 20, Mo.

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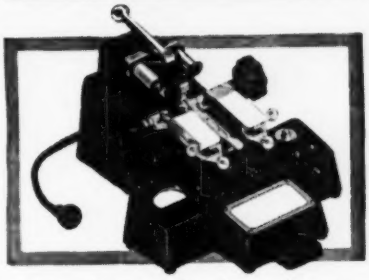

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Journals Available and Wanted

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Available

Journals from July 1948 through December 1954, including extra numbers, directories, indexes, etc. Excellent condition. $30.00 FOB. Write Hal Mayforth, 4812 Cooper Lane, Hyattsville, Md.

Dec., 1936; Jan.–Feb., Apr., May, July, Sept., Nov. 1937; 1938 complete; 1939 complete; 1940 complete; Jan.–Aug. 1941. Write Edward S. Harkness, Werner Horn Inc., 625 Madison Ave., New York, 22.

Collection of back issues available either singly or as a lot. Write F. H. Cole, 1268 So. Ramona Ave., Los Angeles 19.

Wanted

Complete set of Transactions. Write John Flory, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

High-Speed Photography, Volumes 1, 2 and 3. Write Jack Gerbus, Atomic Research Foundation, Technology Center, Chicago 16.

Transactions Nos. 6 and 9. Write W. W. Hennessy, 502 West 41 St., New York.

Signal Corps Pictorial Center could use a complete set of Journals, preferably as a donation. Write John P. Byron, Motion Picture Specifications, Signal Corps Pictorial Center, 35-11 35 St., Long Island City 4, N.Y.

Transactions Nos. 1, 5, 6, 7 and 9. Write Lloyd E. Varden, Pavelle Color Inc., 533 West 57 St., New York 19.

Meetings

76th Semiannual Convention of the SMPTE, Oct. 19–23, Ambassador Hotel, Los Angeles

National Association of Educational Broadcasters, Oct. 27–30, Hotel Biltmore, New York

Theatre Equipment and Supply Manufacturers' Association (T.E.S.M.A.) Annual Trade Show, with exhibits, Oct. 31–Nov. 4, Conrad Hilton Hotel, Chicago

Adult Education Association, National Conference, Nov. 3–10, Hotel Sherman, Chicago

National Electrical Mfrs. Assn., Nov. 8–11, Ambassador Hotel, Atlantic City, N.J.

SMPTE Central Section, Nov. 15, Dec. 19; Jan. 17, Feb. 21, Mar. 21, May 16, June 13, 1955

Audio Engineering Society, Nov. 18–20, Austin, Texas

75th Semiannual Convention of the SMPTE, Apr. 17–22, 1955, Drake Hotel, Chicago

The International Commission on Illumination is to hold its next international conference in Zurich, Switzerland, June 15–22, 1955.

Officers of papers should be addressed to the Chairmen of the Papers Committee (A. A. Brainerd), 1015 Chestnut St., Philadelphia 7. Manuscripts must be in the hands of the Central Screen Editors Oct. 1 and Dec. 31, 1954.

Biological Photographic Association, Annual Meeting, Aug. 30–Sept. 2, 1955, Wisconsin Hotel, Milwaukee

76th Semiannual Convention of the SMPTE, Oct. 2–7, 1955 (tentative), Lake Placid Club, Essex County, N.Y.

Photographic Society of America, 1955 Convention, Oct. 5–8, 1955, Sheraton-Plaza Hotel, Boston, Mass.

77th Semiannual Convention of the SMPTE, Apr. 29–May 4, 1956, Hotel Statler, New York

80th Semiannual Convention of the SMPTE, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles

81st Semiannual Convention of the SMPTE, Apr. 29–May 3, 1957, Sheraton Hotel, Washington, D. C.

82nd Semiannual Convention of the SMPTE, Oct. [illegible] 1957, Hotel Statler, New York

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections Subsections and Chapters, and of the Committee Chairmen and Members were published in the April Journal.

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Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
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